Design Management Phases in a Construction Irrigation Dam: Case Study

By

Rubén Quiñones Martínez

Dissertation submitted to

School of Technology and Management

Polytechnic Institute of Bragança

In partial fulfilment for the Degree of Master in

Construction Engineering

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Coordinator:

Professor Dr. Rui Alexandre Figueiredo De Oliveira

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To my family.

“Nothing good in life comes easy”

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The accomplishment of this research has been a real challenge that required dedication, effort and motivation, and I could not have done it without the help of all the people around me.

To my parents, the support of my life, who never allowed me to give up, being by my side at every moment giving me the energy necessary to always take another step, I can never thank you enough.

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Abstract

Keywords: Management, Project phases, Project Design, Irrigation Dam, Stakeholders

An efficient management of construction projects plays a fundamental role to reach the objectives and guarantee success during the project development design and construction. This management involves an orderly, sequential and efficient effort, carried out with experience and responsibility in the development of each phase of a construction project.

Currently, technical, environmental, economic and social regulatory requirements regarding construction project development have become more demanding, especially in larger scale projects with increased technical complexity.

This research develops the procedural basis of documentary management of projects in different phases of development, using an exhaustive literature review, denoting some differences and particularities amongst countries and even amongst authors, especially in organization procedures.

A case study was conducted comparing the regulatory assumptions and the relevant literature on the subject with the real management of a construction project of an irrigation dam. Firstly, a review of the various documents that constitute the dam project design along the different phases of its development was undertaken. Subsequently, in order to complement the gathered information during the investigation, as well as to respond to other missing research questions even after the documentary review, an interview supported by a questionnaire with the dam project designer was conducted.

The main results of the research allow the convergence of scattered and unclear information about which documents are mandatory in each phase of the project, being this unclearly specified in the regulations.

The case study contributes to understanding the role of the different stakeholders throughout the process, and the criteria that support their decisions to move forward to the next phases of a project. Besides, the case study allows a better comprehension of the milestones to complete a phase and to start the next one, as well as to ensure all the necessary supporting documents in the different phases.

Resumo

Keywords: Gestão, fases do projeto, projeto, barragem, stakeholders

A gestão de projetos de construção tem um papel fundamental para o cumprimento dos objetivos e garantia de sucesso durante a fase de elaboração do projeto e consequentemente na construção do empreendimento. Esta gestão envolve um esforço ordenado, sequencial, eficiente, desencadeado com experiência e responsabilidade no desenvolvimento de cada fase de um projeto de construção.

Atualmente, os requisitos regulamentares de nível técnico, ambiental, económico e social, têm vindo a tornar-se mais expressivos em termos de exigências, especialmente em projetos de maior escala e de complexidade acrescida.

Este artigo desenvolve a base processual da gestão documental de projetos nas diferentes fases de desenvolvimento de um projeto, recorrendo a uma exaustiva pesquisa de revisão bibliográfica, denotando-se que existem algumas diferenças e particularidades entre países e mesmo entre autores, sobretudo no que se refere à organização.

Deste modo, foi alvo de um estudo de caso, a comparação entre os pressupostos regulamentares e bibliografia sobre a temática, com a gestão real de um projeto de construção de uma barragem de regadio. Em primeira instância foi realizada uma consulta dos diversos documentos que compõem o projeto da barragem nas diferentes fases de desenvolvimento do mesmo. Posteriormente, e para complementar os dados obtidos na investigação, bem como dar resposta a outros omissos com a consulta documental, aferiu-se a realização de uma entrevista apoiada por questionário junto do projetista da barragem.

O estudo de um caso real de um projeto de construção de uma barragem permite aferir além dos documentos necessários em cada fase do processo de desenvolvimento do projeto, qual o papel de diferentes intervenientes ao longo do processo e de quais os critérios que suportam as suas decisões de passagem às fases seguintes de um projeto.

Além disso, o estudo de caso permite ainda compreender os ponto chave para terminar uma fase atual e iniciar a seguinte e também assegurar todos os documentos de apoio necessários nas diferentes fases.

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1 Introduction

1.1 Objectives

The main goal of this research is to apply the real studies and correct application of the construction Project Design phases, from the Feasibility Phase, through various stages of the Project Design, specifically: Programming Phase, Schematic Design Phase, Design Development Phase, and Construction Document Phase. The basis of this discussion lies on trying to prove the existence of divergences between what is defined by the regulations and what is effectively developed in each phase of the Project Design.
In summary, three main specific objectives can be highlighted:

- To recognize and catch accordingly with current regulations, and based on bibliographical review, the Project Design management life-cycle from the conception to the closeout, considering the particularities of the different stages.

- To explain the development of a real case study, based on an irrigation dam in Bragança.

- To understand the differences between a theoretical Project Design management developed according to the current regulation and a real situation Project Design.

1.2 Research methodology

Research can be understood as a search for knowledge. The Advanced Learner's Dictionary of Current English lays down the meaning of research as "a careful investigation or inquiry specially through search for new facts in any branch of knowledge."

According to Barbosa and Melo (2005), methodology refers to the paths followed along with the research, which must be presented in the same chronological order as the work has been developed.

The purpose of the research is to discover the answers to the posed questions by the submission of scientific procedures. The aim of the research is to find out the truth which is hidden and which has not been discovered as yet. Since each research has its own specific purpose, we may classify the research objectives in the following broad groups (Kothari, Research Methodology. Methods and Techniques, 2004):

1. To gain familiarity with a phenomenon or to achieve new insights into it;

2. To portray accurately the characteristics of a particular individual, situation or a group;

3. To determine the frequency with which something occurs or with which it is associated with something else;

4. To test a hypothesis of a causal relationship between variables;

The research methodology is based on a qualitative exploratory model, with a detailed description of the developed system, and supported by the nature of a group of factors related to the management of this kind of Project Design (Yin, Case Study Research. Design and Methods, 2003).

In this research, the collection of information related to the construction Project Design begins with a bibliographic review from different authors who gave their own points of view based on the gained experience and the regulations of each country. Sometimes, this subjective approach requires to sort all the information in order to remain with the most trustable information and stablish a solid basis from where the research can be developed to give answer to all the questions and to satisfy all the objectives.

In order to complete the lack of information from the bibliographic review, the collection process moves to the documentary review, because it can broaden the information as well as to verify the information acquired so far during the previous phase. In some cases, like in the dam construction project of Rebordãos, the companies are willing to help and to provide all the necessary information, but some other times, the main problem lies on the availability of this kind of documents, because they prefer to keep them as confidential.

Finally, the collection process finishes with the elaboration of interviews to the participant members of the Project Design, like in this case, to the project manager, aiming to a better specificity of the written and designed contents for the different phases, as well as to complement the justification of the divergence with the legal framework.

However, there are limitations related to the interviewees:

- A reduced number of people involved.
- Few technical knowledge about the subject.
- Basic training.
- Work area.
- Personal interests and approach.
- The geographic area of intervention.

1.3 Structure of the report

This report is organized in 5 chapters and appendix as follows:

The first chapter, titled “Introduction”, refers to the initial aspects of the work, namely the main objectives of the research and a description of the research methodology applied.

On the second chapter, titled “Project Design Phases”, based on the bibliographic review methodology, the different phases of a construction Project Design are highly detailed, such as Feasibility Phase, Programming Phase, Schematic Design Phase, Design Development Phase, and Construction Document Phase. The national regulations and technical specifications, as well as the bibliography from different authors regarding construction Project Design management, were considered taking care of the subjective information in order to get trustable results for the research.

The third chapter, titled “Research Methodology”, explains the different methods to collect information in a research. The methodology applied in this research is highly detailed, with special interest in the qualitative approach by the application of the study case method and the gathering of information appealing to the interview process.

On the fourth chapter, titled “Case Study”, is described this method to collect information, in order to satisfy all the questions posed after the bibliographic review.

To achieve this, two tools were applied on this research.

On the one hand, the documentary consultation from the irrigation dam construction Project Design in the Ribeira de Rebordãos. On the other hand, questionnaires were elaborated as a part of the interview process, thanks to the participation of active members of the Project Design.

Finally, the fifth and last chapter, titled “Final Conclusions”, a final review of the research is made, explaining the main conclusions obtained from it, as well as the analysis of the future expectations of the construction industry.

2 Project Design Phases

2.1 Context of the Construction Sector

2.1.1 Current Situation of the Construction Sector

The construction sector, participates directly in the economy of the countries, being responsible for the creation of added values and jobs, being in many cases a great reactivator of the economy of those countries.

The main goals of civil engineering projects are complex and demanding from the technical, economic and social point of view, aiming to improve the organization of the territory, sustaining cities, improving the quality of life of the population, meeting mobility needs, or managing water resources, among others.

Currently, due to the growth of the environmental conscience, research are being carried out to make construction more efficient and ecological, seeking to optimize and develop techniques that allow greater control over emissions and the consumption of the resources, such as energy efficiency, water reduction or construction products impact.

However, the implementation of new technologies is in constant development, allowing a greater control over those variables and uncertainties that can be taken into consideration, making sure that the projects are carried out with greater safety and efficiency.

2.1.2 Dimension of the construction sector in Europe

The economic forecasts for upcoming years, as shown in Figure 1, tend to fall, contemplating a continuation of the positive trend in 2020 (1.6%) and 2021 (1.3%) but at rates lower than those of the economy (Euroconstruct, November 2017).

In the period 2019-2021, there will be half a dozen countries growing at rates above 3%, and the cases of countries in the negative zone are limited to three, being the countries with the lowest growth rate the United Kingdom, Germany and Italy.

Figure 1. Economic Forecast by Country (Euroconstruct, November 2017)

Residential construction goes from the notorious growth of 2018 (5.5%) to a virtual stagnation in 2020 (0.3%) and 2021 (0.1%), as reflected in Figure 2.

Non-residential construction, due to the lack of new territory supplies, will continue growing, bun at rates underneath the rest of the economy through the period from 2018 (1.7%) to 2021 (1, 4%).

Civil engineering construction projects could partly fill the void created by the stagnation of the new plant housing. The production from the construction of infrastructures has grown significantly in 2018 (5.0%) and a similar 2019 is expected (4.5%). Most of this growth will come from transport infrastructure.

The European Union has set ambitious climate and energy targets for 2020 and 2050, in order to boost the energy savings of the buildings, turning this into a priority objective.

Community directives have been approved to be taken into account in the building renovation sector. Good examples of theses directives are the 2018/2001/EU based on the promotion of the use of energy from renewable sources and the directive 2010/31/EU based on the energy of buildings.

Many legislative initiatives have been also introduced for building renovation, like the Energy Performance of Buildings Directive (EPBD) in 2010, which introduced the requirement of implementing energy efficiency measures for building renovations, as well as the Energy Efficiency Directive complements the EPBD which required, in 2008, to the EU countries, strategies for the renovation of national building stocks by April 2014, as well as to renovate 3 % of the building stock of central governments annually to a high energy performance level.

Figure 2. Economic Forecast by Sector (Euroconstruct, November 2017)

2.1.3 Dimension of the construction sector in Portugal

The construction sector in Portugal, experienced a drop since 2002, basically due to the global economic crisis. This involved a decrease in the relevance of the sector in the national scope.

The distribution of this decrease in terms of the different sectors is reflected in Figure 3, with residential construction being the most affected sector (AECOPS).

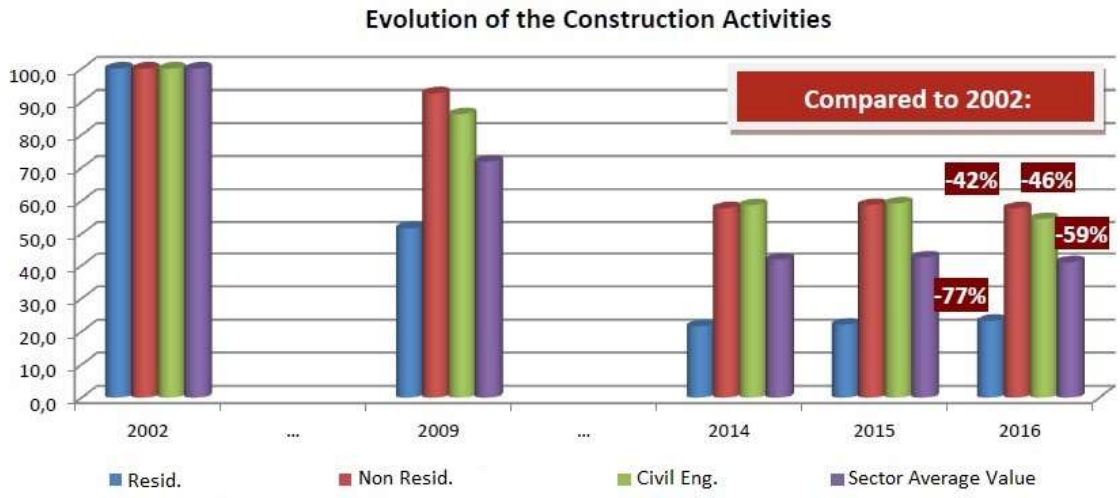

Figure 3. Evolution of the construction sector by activity field.

The number of projects decrease that were executed implied that the number of companies that went bankrupt or that ceased their activity increased considerably, as can be seen in Figure 4, until reaching a minimum value in 2016.

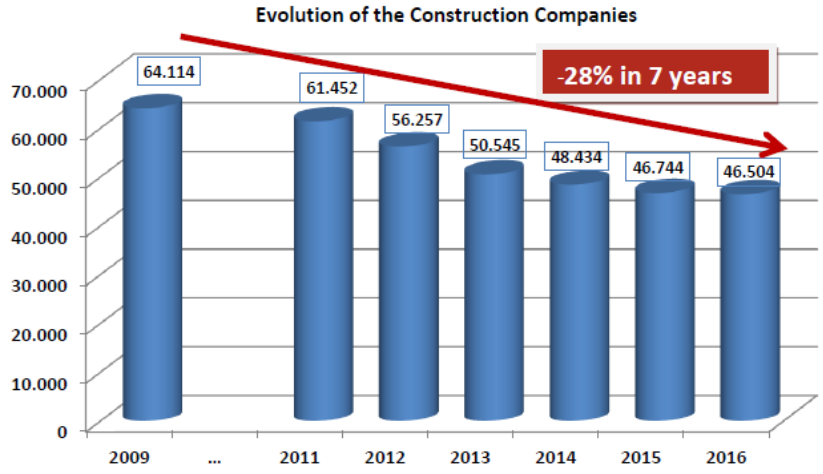

Figure 4. Evolution of construction companies.

Moreover, as shown in Figure 5, this influenced the presence of the construction sector in the national GDP, reducing to values close to 3%.

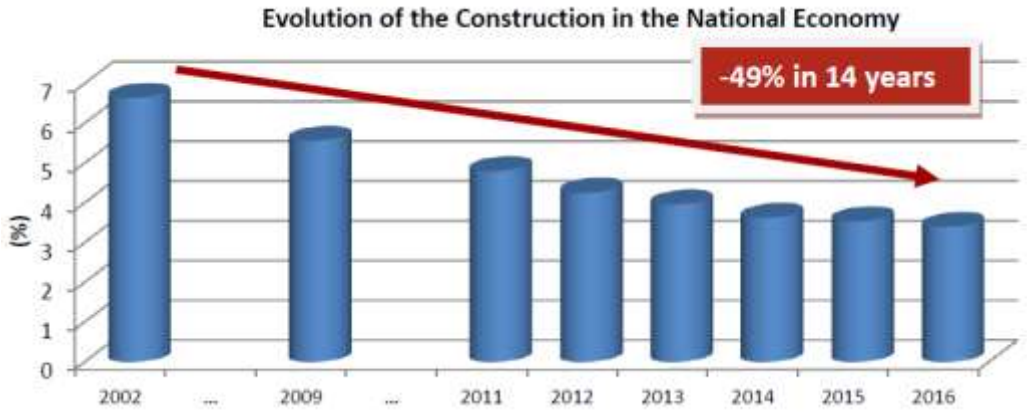

Figure 5. Evolution of the construction in the national economy.

As per Euroconstruct estimates, the development of the construction sector in Portugal will develop by 7.1% between the years 2018 and 2020, higher than the rest of the EU countries.

The leader sector will be the building rehabilitation and renovation sector with an expected to grow tax of 12.2% over the next two years.

New houses construction will proceed, with a projected increase of 4.5% for these three years, while for new non-residential buildings the average annual will increase 4%.

2.2 Construction Project Design Life Cycle

2.2.1 The concepts Project “Project” versus Project “Design”

The concept of the project as a "project" is often confused with the concept of project "design" used erroneously on numerous occasions, causing misunderstanding among the interlocutors. (D. Oberlender, 2000).

Project is a broader concept, ranging from the initial idea of the client, through its development and continuing until its final execution. Thus, the "Project" concept is associated not only with a technical component but also with a financial and management component.

Hence, the concept "Design" refers to the development of the client's idea. This task can be performed by the client's own team or by an external company, having more technical nature and focused on the constructive solutions. Therefore, it can be concluded that the "Design" takes part in the "Project".

2.2.2 Project Design phases

A construction Project Design is the result of an orderly, clear and controlled management of a group of elements, which together, allow to reach safely and reliably the established objectives of the Project Design. In a construction Project Design is important to identify the stakeholders who will take part in the elaboration of the Project Design, in order to establish a hierarchy in which each individual belongs to a system that works coordinated and efficiently.

It is important to establish the life cycle of our Project Design so as to keep a clear sequence leading to a full control of the situation to prevent the possible unforeseen events that may occur.

According to Decree-Law 701H-2008 published the 29th July 2008, the different phases that will constitute the life cycle of the Project Design, as shown in Figure 6, are:

- The Feasibility Program,
- The Programming Phase,
- The Schematic Design Phase,
- The Design Development Phase,
- The Construction Document Phase.

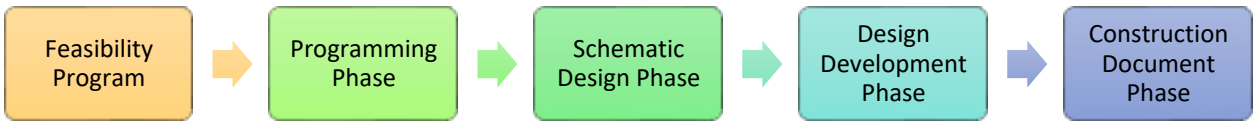

Figure 6. Construction Project Design life cycle development

2.3 Feasibility Program

2.3.1 Phase Description

Feasibility Program is, according to Ordinance 701-H/2008, "A document produced by the owner and provided to the tenderer to clarify and define the objectives of the project, its organic and functional characteristics, and the financial constraints, as well as the different costs and the considered execution timeframe".

The promoter, at this stage, is responsible for establishing the objectives, which will serve as guidance to develop the Project Design.

This stage has the following main goals:

- To specify the goals and objectives along with the life cycle of the Project Design.
- To propose possible alternative for the project.
- To select the most suitable option, based on a value-risk analysis.

There are some restraints that may influence the establishment of these objectives and that should be considered before taking any relevant decision, such as (The Chartered Institute of Building, 2002):

- Time.
- Cost.
- Performance.
- Location.
- Quality.

2.3.2 Owner's Objectives

The needs for a project by the owner, responds some important issues such as market demand, or a customer request or a social need (J. Smith, 2002).

Owner needs to design and construct a facility, based on a demand of the society or a customer request or a personal ambition, or by any other reason.

The impact of the owner's study (Objectives, deadlines, ideas, budgets, among others) on the design of the project and its construction phases, depends on the complexity and context of the project under study.

The first step to accomplish this project consists on setting the objectives, because it permits a correct development of the scope definition, as well as to guide the design process and to keep the focus of the project team (D. Oberlender, 2000).

The setting of the project objectives aims to optimize the aspects related to the minimum requirements of quality, an approved maximum budget, and completion deadlines, and it is considered as a guideline to be taken into account in all the decisions that will be made throughout the different steps of the Project Design.

The task of establishing the objectives and identifying the needs of the client is not individual, but there is a complete Project Design team involved to achieve the best possible outcomes. Among the members of this team we can find:

- Project managers.
- Investors.
- Jurist.
- Administrative personnel.
- Financial personnel.
- Engineers.
- External consultants.

2.3.3 Project Design Brief

The Project Design brief is a document that must be delivered by the owner to the tenderers to carry out the Project Design and that contains all the information relevant to its development. According to the public projects regulation, there is a minimum number of elements that must be delivered in order to limit the expenditure of time and resources.

All information must be provided is the following:

- Basic information regarding the performance, operation, and maintenance based on regulation.

- Final budget estimate and deadlines.
- General characteristics of the work, such as location and objectives.
- Technical aspects of greater relevance, such as studies carried out (geotechnical, cartography, access network, environmental aspects, among others).

The Project Design Brief is divided into two phases, which are developed as the definition of the Project Design progresses:

- Detailed Project Design Brief: iterative process in which the Project Design team participates and where it is considered a wide range of assumptions that condition the Project Design and give as a result the budget approval.
- Detailed Design Brief: includes all the elements of the Detailed Project Design Brief, including the budget acceptance, which is considered realistic, allowing the Project Design to move forward to the next phase.

The development of the Project Design brief is shown in Figure 7.

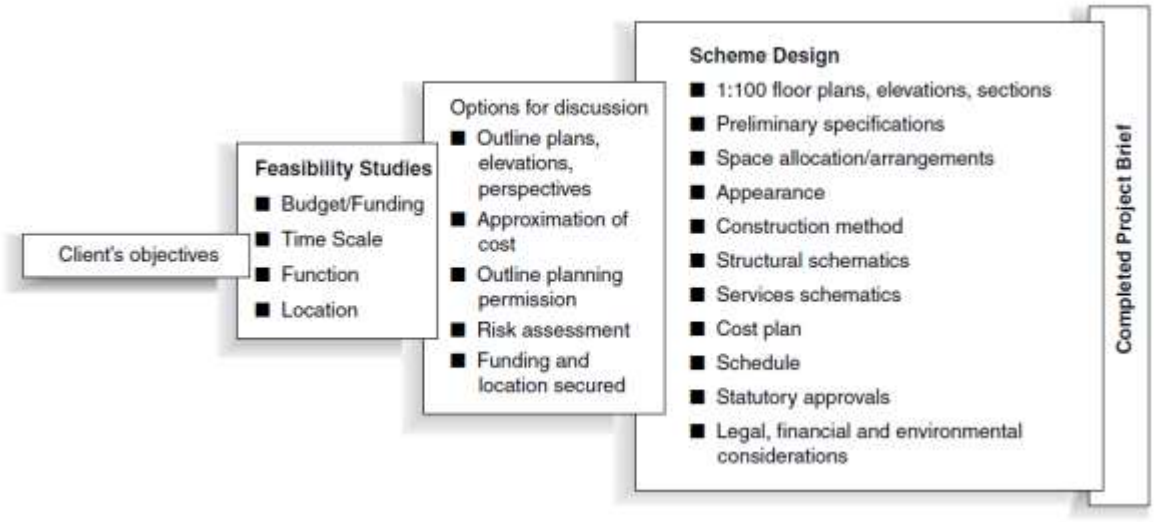

Figure 7. Scheme of a Project Design brief (The Chartered Institute of Building, 2002).

The feasibility study is considered a key document of the Project Design brief, which, based on the quantitative aspects of the Project Design, determine whether it is reasonable to continue with the Project Design or not, despite the resources invested. In case of complex projects, more exhaustive studies could be required to support the decision making (Department of Finance, 2009).

Making the decision to continue or abandon a Project Design requires the analysis of a series of previous studies that aim to satisfy the main objective, which in many situations is to obtain the higher profit (Dias Pereira, 2015).

The conflict between the motivation of the Project Design with the technical and legal aspects is taken into account. This results in the proposal of different technical alternatives (regarding the location, the processes, the materials, among others).

In Figure 8, is represented how the investment curve varies, reflecting the benefits of the client during the initial stages before the development of further stages of the Project Design, and how the investment-benefit ratio varies throughout the life of the Project Design.

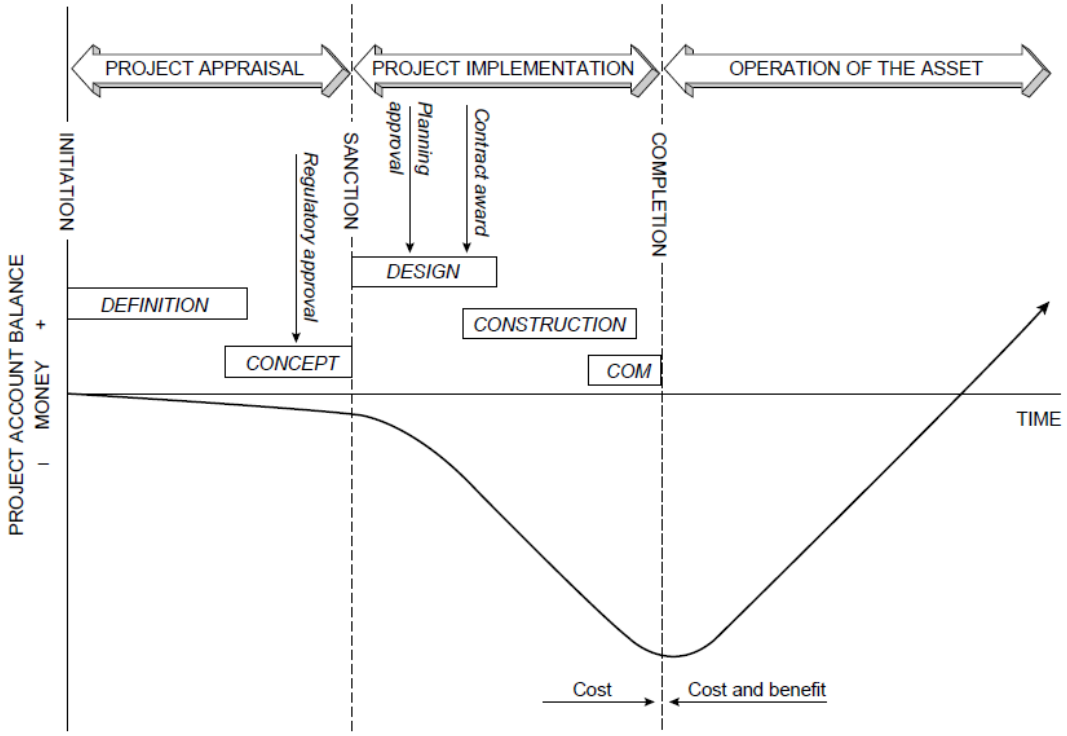

Figure 8. Investment curve variation along the Project Design life cycle

It is very important, at this point, to be conscious enough whether the Project Design is favorable or not, to take the decision to continue, abandon or to look for alternative ideas.

The main content of a feasibility study should include the following items:

- Studies on requirements and risks.
- Public consultation.
- Geotechnical study.
- Environmental study

- Legal/Statutory/Planning requirements or constraints.
- Estimate of capital and operating costs.
- Assessment of potential funding.
- Potential site assessments.

The most frequent analysis model is the SWOT analysis (Strengths-Weakness-Opportunities-Threats). This model analyses all the external and internal factors that may have an impact on the feasibility of the Project Design:

- Strengths: internal attributes and resources that work for the success of the Project Design.
- Weaknesses: internal attributes and resources that work against the success of the Project Design.
- Opportunities: external factors that the Project Design can take advantage of.
- Threats: external factors that can compromise the success of the Project Design.

A different version of the SWOT analysis is the PEST analysis, which studies the surrounding Project Design factors, such as political, social, economic or environmental factors as shown in Figure 9 (P. Cartlidge, 2015).

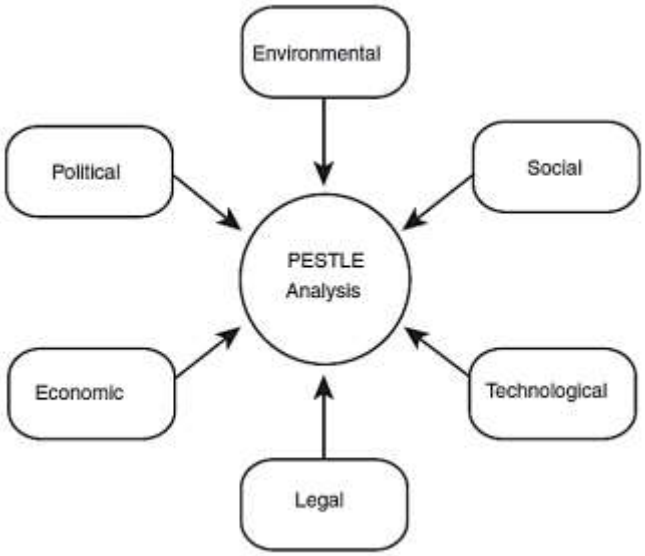

Figure 9. Influencing factors of the feasibility study of a Project Design

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2.3.4 The business case

The business case is a document that allows to assuring the commitment of the owner and the stakeholders, since it justifies the acceptance of the Project Design, demonstrating the balance of the cost against the expected benefits (BIS, 2010). The level of detail depends on the complexity of the Project Design.

To carry out this document, it is mandatory an in-depth analysis, considering the market conditions, the financial aspects, the consequences of delays in deadlines and historical precedents. All this allows to take a justified decision attending to (The Chartered Institute of Building, 2002):

- The required money investment.
- Satisfy the project objectives.
- Affordable and feasible in the time established.
- High-level strategy.
- Clear financial tactics.

2.3.5 Project Design Risk Identification Plan

The risk management process, developed since the beginning of the Project Design and continuously updated along life cycle, consists of identifying all the project risks that may compromise the objectives and to propose preventive actions for each one of them (BIS, 2010).

This process starts with a risk analysis that aims to gather enough information about the risks, such as its occurrence and its consequence and to turn them into a risk level. To accomplish the objective of this analysis, several sources of information are available:

- Analysis of the existing documents.
- Review of similar Project Design.
- Data from experienced personnel.
- Simulation.
- Tests and studies.
- Expert judgment

The approach of these risk can be done quantitatively or qualitatively.

The methodology involved in the qualitative risk analysis is based on risk scales that estimate the probability and consequence of the risk, and with the help of risk matrixes and expert judgment it gives as an outcome a risk rating definition (Kerzner, 2009):

- High risk: High-priority management attention is required.
- Medium risk: Additional management attention may be needed.
- Low risk: Normal management oversight is sufficient.

The methodology involved in the quantitative risk analysis is based on payoff matrixes, decision trees), expected value or Monte Carlo simulation, which incorporates a model structure and a probability distribution.

In order to turn this quantitative analysis into a risk level, the risks can be classified according to the cost, the schedule or the technical boundaries.

2.3.6 Project Design Communication Plan

A Project Design communication plan aims to ensure that all the Project Design members receive the needed information in correct time. This control of the information is critical to avoid loss of information or misunderstanding along the life cycle of the Project Design.

The content of a Project Design communication plan should provide the following information (W. Larson & F. Gray, 2011):

- The information that needs to be transmitted and the information that needs to be collected and when.
- The timeframe for the information to be transmitted.
- The responsible to transmit the information.
- The consignee of the transmitted.
- The chosen method to transmit the information.

2.3.7 Transition to next phase and Decision making

The analysis of the results of all the studies that have been made along with the Feasibility Phase, produced the following outputs (PMI, 2000):

- Project Design charter - Document that allows the Project Design to move forward into the next phase.
- Manager team - Assignment of the Project Design manager/team.
- Restraints - Factors that condition the evolution and development of the Project Design.
- Assumptions - Elements assumed to be certain, even though it is implied a degree of risk.

Once the decision of acceptance of the Project Design is made, the next step aims to develop the Project Design proposal itself, based on its specialties, such as architectural and engineering reports, with the objective of giving an answer to specific matters and solutions of the Project Design.

2.4 Programming Phase

2.4.1 Phase Description

The Programming Phase is in accordance with Ordinance 701-H / 2008 published 29th July 2008, the first phase that will be developed by potential tenderers to execute the Project Design.

Based on the statements of the Feasibility Phase, each tendering company will submit, in a particularized way and verifying its feasibility in all the domains, a number of alternative proposals, as suitable as possible to the conditions and objectives established by the Project Design team and by the owner of the project.

Once these proposals have been evaluated and approved by the client, the Project Design will move on to the next phase, in order to accomplish a deeper development of the proposals (Dias Pereira, 2015).

The main content of the alternative solutions is compounded by the following elements:

- Contextualization of the works planned to be done including a sequence of the tasks that will be performed.
- Justification of the constitutive elements design criteria of the alternative solutions.
- Statement of the Project Design constraints, such as surface occupation, topography, geomorphology, climatic aspects and also from the point of view of the infrastructures, such as services or accesses.
- Written and drawn parts necessary for a better understanding of the proposed alternative solutions and that permit to verify their feasibility according to the established conditions in the Feasibility Phase (technical, economic, financial, social and deadlines).
- Project Design budget estimate, not only regarding the cost involved in the Project Design construction but also regarding the administrative cost and the studies carried out.
- Estimate of the project maintenance and conservation cost of each one of the proposed alternative solutions.
- Requirements for the operation, exploitation, and conservation of the Project Design proposals.
- Additional information (geology, hydrology, topography), necessary to a better discretization of the situation and that influence the proposed alternative solutions.

2.4.2 Professional License.

According to Decree-Law 69/2011 published in 15th June 2011 and Ordinance 18/2004 published in 10th January, all contractors could not have access to all type of public or private projects. A Project Design execution capacity, based on a given budget, is defined by a permit issued by IMPIC to the contractors.

The license that companies hold, establish the type of works, for which they must be qualified. These qualifications relate to a subcategory of the established categories in a given class, according to the existing regulation.

In the particular situation of small projects, companies do not need these qualifications, due to the Law n. º 18/2018 published in 14th June, which modifies the Law n. º 41/2015 published in 3rd June, allowing, by mean of a certification, to undertake projects under two circumstances:

- Construction projects whose budget doesn't exceed the 20% of the limit budget fixed for Class 1.
- Activities included in the Appendix II of the Law n. º 18/2018:
  - Masonry, plastering and laying of masonry.
  - Stucco, paint and other coatings.
  - Carpentry.
  - Work on non-structural profiles.
  - Plumbing and ducting in buildings.
  - Installations without specific qualification.
  - Restoration of historic-artistic real estate.
  - Footwear.
  - Landscaping.
  - Electrical installations for the use of low voltage.
  - Telecommunications infrastructures.
  - Fire extinguishing systems, safety and detection.
  - Heating, ventilation, air conditioning and refrigeration.
  - Gas distribution networks and branches, gas installations and appliances.
  - Centralized technical management.
  - Demolitions.
  - Land movements.
  - Reinforced concrete reinforcement.
  - Formwork.
  - Waterproofing and insulation.

Certain requirements are needed to be granted with a license and to keep it, there are involve technical skills, economic and financial status or legal situation and many other support documents.

2.4.3 Detailed design

The detailed design refers to the development of the concept and technical designs of the project, attributed to the potential design teams, (Design and Build: detailed design, 2018).

Once the owner has updated the Project Design Execution Plan (PEP), the design teams may set up a meeting in order to make/receive comments related to the program and performance recommended to be done, so as to have a better guideline to prepare the Project Design.

The client submits the scope of specifications needed to develop the Project Design, and the design teams must coordinate the sourcing of all the equipment, components and materials required. The economic estimate of the proposal is also submitted, regarding the cash flows and the cost plan, and a report is issued to the client describing the detailed design in order to be reviewed.

Ending the review, the client may decide to accept, reject or ask for correction within a specified time.

The design teams, with the help of specialist subcontractors, coordinates the development of the technical design, setting all the structural, mechanical and performance questions of the proposal.

After the review of the technical design, the design teams set up a meeting to outstand what needs to be amended and updates the cost plan and the cash flow of the proposal. After the review, the technical design report is issued to the client, who will take the decision of accepting, rejecting or amending the design within a specified time.

2.4.4 Transition to next phase and Decision making

The acceptance of the detailed designs by the client works as a milestone which permits moving on to the next phase, the Schematic Design Phase. During the Design Phase, the approved solution will be iterated to achieve a greater detail and comprehension.

2.5 Schematic Design Phase

2.5.1 Phase description

The Schematic Design Phase is, according to Ordinance 701-H/2008, elaborated by the design team and issued to the owner, and it develops the approved solutions in the Programming Phase.

It is composed of written and drawn pieces and other informative elements in order to allow an easy understanding of the solutions. Usually, the main content of a Schematic Design Phase consists in:

- The descriptive and supporting report, as well as a description of each one of the objectives of the Schematic Design Phase.
- Scaled graphics elements.
- Approximate dimensioning and description of the main elements of the work;
- General description of the materials, equipment, and their performance.
- Analysis regarding the thermal behavior, acoustic, energetic and quality.
- Budget estimation and deadlines.

2.5.2 Project Design Scope Definition

Project Design scope definition is a document, elaborated by the design team, that outline the content of the Project Design to reach the client´s objectives (PMI, 2000). It subdivides the main Project Design into small deliverables and describes how the works will be executed and who will do each one of them.

The most common method has its basis on the Work Breakdown Structure (WBS), a method that turns the project into a map, that identifies all the deliverables and project elements. After the identification, it subdivides the work elements into smaller and more manageable pieces to integrate them into the project organization so it can establish a procedure of control, as shown in Figure 10 (PMI, 2000).

The sequence to develop the WBS structure consists in:

1. Identification of the major Project Design deliverables.
2. Definition of the sub-deliverables necessary to accomplish the major ones.
3. Iteration of the process until small manageable processes.

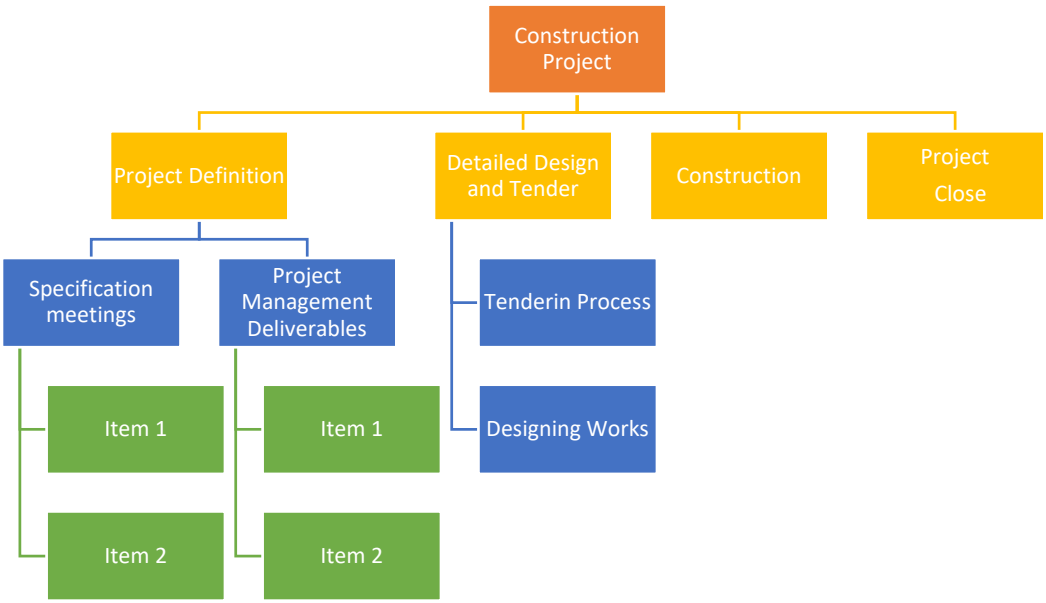

Figure 10. WBS Template of a construction Project Design

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Despite the fact of the investment required to develop the WBS, it permits to evaluate the schedules, performance, and budget in all the organization levels along with the project life (W. Larson & F. Gray, 2011). Given the hierarchical organization achieved, it leads to a better definition of the responsibilities and coordination of all the Project Design participant members.

Each WBS element identifies (W. Larson & F. Gray, 2011):

- Works to be done.
- Process timeframe.
- Process budget.
- Process resources.
- Process responsible.
- Process monitoring system.

The main checklist of the scope definition includes (W. Larson & F. Gray, 2011):

- Project Design objective.
- Deliverables of the Project Design.
- Milestones definition to identify the deliverables and their deadlines.
- Technical requirements for correct performance.
- Constraints and exclusions.
- Customer reviews.

2.5.3 Regulation guideline

Giving the complexity of the construction projects and their impact in so many aspects, such as technology, economy or society, the regulation establishes some checkpoints along with the life of the Project Design to make sure that everything is considered and done in the best of the conditions.

Regarding this, there are some guidelines to be followed by the regulation at the Schematic Design Phase:

- Project Design review.
- Duality of proposals.

2.5.3.1 Project Design Review

The construction Project Design review is a process of quality control, whose objective is to minimize deviations in cost and in deadlines, and to verify that the information included in the constructive solutions and specialties is correct and enough (Afonso Parete, 2011).

With the Project Design review being executed at the right time, the following problems can be detected:

- Errors and omissions.
- Constructive methods or inadequate materials.
- Check the correspondence to current standards and certificates.

The design team is required to provide this information and to provide clarification to continue with the normal development of the Project Design.

According to Law 40/2015 of 1st June, the owner can promote a Project Design review, to be executed by a duly qualified entity (different from the design team) in order to continue with the development of the Project Design under the following circumstances:

- A high complexity project.
- Innovative construction methods, materials or techniques used in the project.
- The Project budget higher than class 5 (2.656.000 €).

The client can request the information considered to be necessary, being this one of the main reasons of delays and claims in Project Design.

There are different information requests that the client may consider:

- Alternative solutions - request for proposals of alternative solutions to the Project Design.
- Approvals - documents delivered to the client to receive approval (designs, technical specifications).
- Clarification of information - request for complementary information or clarification of the provided information.
- Verification of information – request to refute the existing information.

2.5.3.2 Project Design Proposal

At this point of the Schematic Design Phase, the design team must submit the Project Design proposal to the client in order to check and decide if they can continue on its development or if that proposal is discarded. This process is one the milestones of the Project Design, because the client is compromised with one Project Design, rejecting the rest of the proposals.

According to Ordinance 701H-2008, two alternative proposals must be submitted, at the Schematic Design Phase, under the circumstances of works belonging to category III or IV (Hydraulics works or Electrical and mechanical installations), in order to evaluate them and take a decision.

2.5.4 Transition to next phase and Decision making

Once the client has accepted the solution of the design team, the Project Design can move on to the next phase, the Design Development Phase, which consists of developing in greater detailed the accepted solution. This phase will lead the project to a greater clarification in order to a better comprehension of how it will be developed and organized.

2.6 Design Development Phase

2.6.1 Phase description

The Ordinance 701H-2008 refers that the Design Development Phase develops the solution approved by the owner, setting the background that will lead to the next phase, the Construction Document Phase. It develops and specify the written and drawn elements that help to clarify and define the work planning properly and the way in which it is going to be executed.

The Design Development Phase should contain the following information:

- Descriptive and justifying memory of each one of the elements which constitute the Project Design of the final solution.
- Assessment of the type and quantities of works to be done.
- Updated budget estimate.
- Drawn elements, at convenient scales, and other graphic elements that explain the planimetry and altimetry of the different components of the work, and that strictly define their dimensioning.
- Workplace identification, as well as all the spots reserved to the equipment, facilities, warehouses and networks.
- General work planning.

2.6.2 Environmental Impact Assessment

The protection of the environment has become one of the biggest concerns of the European Union, since the construction industry has a direct effect on the environment, such as noise, dust, solid and pollution.

To control the impact of the construction activities, environmental management systems are applied, focusing on the awareness and knowledge as main factors to intensify the sustainability.

The purpose of the Environmental Impact Assessment (EIA) is to make sure that the side effects of the construction projects are properly considered.

Prior to the EIA procedure commencement, the design team must submit to the authority an Environmental Impact Declaration (EID) in order to prove the will to execute the Project Design.

The authority, within 5 days, will constitute an assessment committee (External entities opinion might be required), to submit the Scope Definition Proposal (SDP) that will be analyzed within 15 days.

The report of the SDP must be presented to the committee within 5 after the conclusion of the evaluation. The final decision will be made, as maximum, in 30 days after receiving the SDP, being the design team notified with the elements that need to be integrated in the EIA within a maximum of 5 days.

This process creates a bond between the design team and the EIA Authority for 2 years, except in the case of circumstantial modifications.

The Decree-Law nº 152-B/ 2017, that transpose the Directive 2014/52/UE, refers to all the construction projects, public or private, which influence the environmental scope and that can produce significant effect over the environment, required and Environmental Impact Assessment (EIA), in collaboration with the following entities:

- Licensing Entity or competent to authorize the Project Design.
- EIA Authority.
- Assessment Committee.
- EIA National Authority.
- EIA Advisory Board.

The most important deliverables in the Environmental Impact Assessment are the following:

- Environmental Impact Study (EIS): issued by the owner in accordance with the EIA protocol, it identifies and studies the impacts that the execution of the Project Design may have, both positive and negative and it also evaluates the non-project scenario. A package of measures is proposed in order to reduce and minimize the effects of these impacts.
- Scope Definition Proposal (SDP): previous to the EIS and issued by the EIA authority, identifies the elements the most affected by the project and that require special consideration.
- Environmental Impact Declaration (EID): it's a document that certifies or not the feasibility in environmental terms of the project.
- Environmental Compliance of Execution Project Report (ECEPR): document elaborated by the design team to verify compliance of the execution project according to the EID.

2.6.3 Construction and Demolition Waste Plan

Portugal, as well as the rest of the EU countries, produces a significant volume of construction and demolition waste. This waste comes from the construction of buildings and infrastructures, partial or total demolitions, and some of them can be toxic, radioactive and dangerous, not only for the environment but also for the workers and people related to these works.

In the particular situation of the construction sector, the task of management and control of these wastes is more complicated due to the temporary nature of the works and the geographic dispersion.

This is the reason why the EU countries are introducing regulations to apply the principles of prevention and reduction and the hierarchy of waste management operations.

One of the most useful techniques to reduce the amount of Construction and Demolition Waste is the LEAN technique. It consists of reducing and removing the activities which doesn't help to optimize the process and empower those principles that help to achieve a more sustainable construction process.

The principles applied in the LEAN technique are shown in Figure 11:

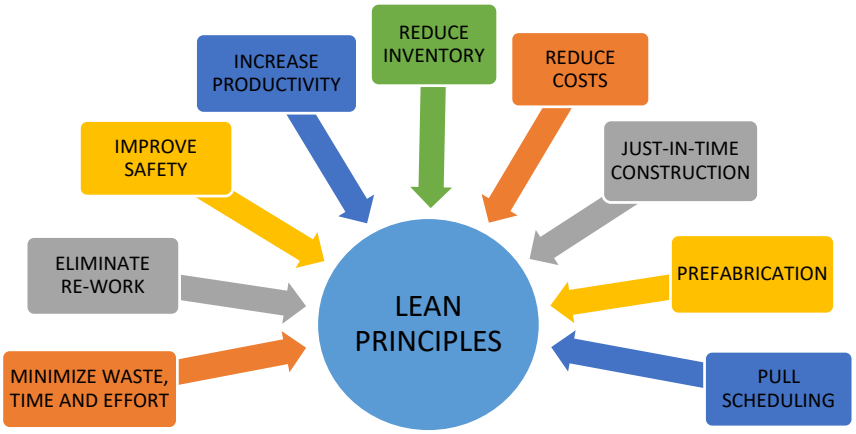

Figure 11. LEAN principles in construction waste reduction

There are sustainability certificates in the construction industry with great relevance and recognition in the construction industry, such as:

- Leadership in Energy and Environmental Design (LEED): is an internationally recognized green building certification that certificates that a community was designed and built using strategies aimed at improving the performance in energy savings, water efficiency, CO2 emissions reduction, and stewardship of resources and sensitivity to their impacts (U.S Green Building Council, 2019).
- BREAM: is a worldwide sustainability assessment method to plan projects, infrastructure and buildings from new construction to in-use and refurbishment, that helps to protect the natural resources.
- Sustainability Building Tool (SBTool): is a generic framework born in Canada used as a toolkit to rate buildings and projects based on the same principles as LEED and BREAM certifications.

According to (Decree Law n.º 46/2008, 2008), which approves the Construction and Demolition Plan Protocol, public projects must include a plan for the treatment of construction and demolition waste (CDW), which includes measures to prevent the waste production, as well as procedures related to collection, transport, storage, sorting, treatment, recovery and disposal.

This regulation also requires, in public projects, that the Schematic Design Phase must be accompanied by an CDW Prevention and Management Plan (PMP) which ensures compliance with the general principles of management of CDW and that should be available in the Work in case of inspections and for everybody to be aware and involve on it.

The main content of a CDW Prevention and Management Plan is compounded by the following elements:

- Characterization of the works to be done, in terms of the techniques (maximization of the materials use, sustainable demolition) or materials (recyclable materials, valuable wastes, production of dangerous substances or CDW).
- CDW Preventive methodology, identifying and estimating the material to be reused, with the European waste code identification system (RSI code), according to Directive 2008/98/EC, and when and where they will be reused.
- CDWs packaging sorting methodology.

Once the works start, the contractor is responsible to accomplish the PMP, taking into consideration the following guideline:

- To foster materials recycling and utilization in the Work.
- To make sure, suitable packaging is available in order to permit proper CDWs management and sorting.
- To develop an adequate storage protocol, so as to keep the CDWs stored the minimum possible time (less than 3 months in case of hazardous waste).

2.6.4 Safety and Health Plan

The Safety and Health Plan is a generic document elaborated at the beginning of the Project Design by the execution responsible during the execution of the work in order to guarantee the safety of the workers. It must be a document in constant evolution and review (Amorim Faria, 2014).

According to the regulation, (Decreto-Lei n.º273/2003 de 29 de Outubro, 2003), published from the Directive n.º92/57/CEE, before the start of the project construction, it should be accomplished a Safety and Health Plan in order to move forward.

The Safety and Health Plan set up the conditions and measures to prevent risks, such as chemical, biological electrical, explosions, and many others.

The Safety and Health Plan should include the following content:

- Documents with analysis and classification of the risks associated to each one of the project tasks;
- Identification of the measures to prevent and mitigate the risks previously identified.

Even though the Safety and Health Plan can get partial approval, the deficiencies should be reviewed before the works start. Thus, the contractor will not be able to start the works until receiving the approval from the owner.

2.6.5 Risk Identification Plan

Risk management identifies all the project risks and provides preventive actions for each risk. It is important for Project Design management to be developed from the beginning of the Project Design and continuously updated along its life cycle (Westland, 2006).

The risk management process consists of (BIS, 2010):

- Plan Risk Management: definition of the strategy and methods adopted to identify and analyze the risks, the proposal of preventive action plans, and the monitoring and control strategy.
- Risk identification.

- ❖ Risk analysis: regarding the probability of its occurrence and its consequences from a qualitative and quantitative point of view.
- ❖ Risk prioritization: determine the urgency and relevance of a risk.
- ❖ Risk management planning: definition of the responsibilities and the mitigation strategy.
- ❖ Risk monitoring and control: evaluation of the adopted preventive and mitigating actions.

2.6.6 Emergency Response Plan

An Emergency Response Plan conduct to a risk assessment in order to identify emergency scenarios enabling to respond effectively and reliably.

The Emergency Response Plan should include the following basic information:

- Address of the Site.
- Date of the Emergency Response Plan elaboration.
- Emergency personnel names and contact details.
- Evacuation routes.

Communication systems should be installed on the Site to be able to contact the emergency services if necessary. This measure is especially important if the Site is located in an isolated area.

Regarding the topic of this research, the construction of dams, it is important to be aware of the regulation related to this kind of projects.

Dam Safety Regulation (DSR) is a document according to which (Decreto-Lei n.º344/2007 de 15 de Outubro, 2007), the measures and protocols to be implemented are defined, in order to control the safety in the dam along with all the Project Design phases.

According to this regulation (Article 45º DSR), an emergency plan must be developed, as well as a warning system.

Besides that, according to Article 46º DSR, the Class I dams (minimum of 25 people under risk in case of accident) must have an Internal Emergency Response Plan (IERP) and an External Emergency Response Plan (EERP).

The Decree Law 344/2007 (Article 53º) states that the EERP is a document issued by the corresponding territorial civil protection entity (CNPC), in line with the IERP. The EERP is updated with a periodicity under the CNPC criteria.

Usually, the main content of the EERP is the following:

- General characteristics of the valley, both downstream and upstream of the dam.
- Flood maps.
- Assessment of potential damages associated with the worst-case scenario.
- Alert and warning system.
- Measures and procedures adopted to reduce the impact of a hypothetical accident.

Decree-Law 344/2007 refers to the Internal Emergency Response Plan (IERP) as a document issued by the owner, with the objective of raising the safety levels and reduce the consequences of the accidents in the dam or the valley that may affect the people, the environment or the equipment.

Since this work refers to a dam project, it is mentioned the procedure to elaborate the IERP in this area. This document must receive the approval form the Dam Safety Authority (DAS) and the National Civil Protection Authority (ANPC). The basis of the IERP is the study of the accidents and the flood wave, as well as to identify the Self-Rescue Area and to implement the warning systems.

Usually, the main content of the IERP is the following:

- Identification of the owner and the responsible to elaborate the IERP.
- General description and characterization of the dam and the valley, both downstream and upstream.
- Monitoring and control safety plan.
- Identification of the accident scenario according to the type of dam and the surroundings.
- Modeling of the adopted accident scenario and additional information.

- Characterization of the most adverse scenario.
- Accident assessment and classification procedure according to the alert levels established by the ANPC and by the DAS.
- Identification of the protocols in case of an accident.
- Identification of the human and technical resources as a warning system to the civil protection authority.
- Identification of human and technical resources as a warning system to the population.
- Accident simulacrum and population awareness measures.

And also, referring to Decree-Law 344/2007 (Article 52.º), the IERP must be updated by the owner and receive the approval from the DAS and the ANPC in the following situations:

- By owner's initiative or by civil protection or authority request.
- Accident occurrence.
- Important modifications of the valley.
- After 20 years of the dam's utilization.

2.6.7 Construction Permits

The licensing of the Project Design is the most complex procedure of the construction Project Design. The design team submit specialty deliverables and wait for the evaluation of the City Hall and the external entities (e.g. LNEC, APA) in order to be able to proceed with the Construction Document Phase.

After the delivery of the documents the team can apply for a construction permit. After the works are completed, the promoter will submit the work book and related documents and request the utilization permission to the City Hall.

The applications for the construction works licensing requires special attention and detail being necessary in the following situations (Lda, 2019):

- Land not covered by a land subdivision operation.
- Land without a specific municipal plan for a specific area.

- Land without any Detail Plan.
- Real estate classified or under way for classification.
- Real estates or land integrated in areas covered by classified or under classification zone.

For the application for a construction license, it is necessary to pay municipal taxes and to deliver all the following elements:

- Identification of the builder with the respective permit.
- Project manager and respective identification.
- Constructor's insurance, civil liability and work-related accidents.
- Construction supervision director.
- Health and Safety Plan.
- Environmental Impact Assessment.
- Work Book with opening terms.
- Proof of payment of construction fees.
- Term of responsibility of the project coordinator.

2.7 Construction Document Phase

2.7.1 Phase description

The Construction Document Phase, according to Ordinance 701H-2008, is the final phase of the Project Design, and it is elaborated issued to the owner for its approval.

This phase develops the Project Design and aims to provide, as clear as possible, all the necessary information and description of the works to be executed to the entities involved (Čukić & Vasiljević).

The main index of a Construction Document Phase is compounded by the following elements:

- Descriptive and justifying report.
- Calculations of the different works in order to verify what is stated in the regulation and to justify the adopted solutions.

- Quantity and quality related to the works to be performed.
- Project Monitoring Plan.
- Prior notification of site works.
- Budget based on the work to be performed.
- Detailed drawings elements to assure a perfect understanding, implementation, and execution of the works.
- General and special technical specifications.

2.7.2 Construction Document Phase Deliverables

2.7.2.1 Descriptive and justifycation report

A Descriptive and justification report is a deliverable, whose objective is to set clear the perspective of the contractor and the justification of the adopted solution. This description should take into consideration all the elements from the different Project Design specialties.

Although it may vary on the complexity and kind of the project, the main content of a descriptive and justifying report is the following:

- General characteristics of the work (objective, location, hierarchy, among others).
- Geological and geotechnical analysis.
- Justification of the work implementation and its integration into other local conditions.
- Justification of the verification of the legal disposals and regulation.
- Shortlisting of materials, installations, and equipment.
- Technical-economic justification.

2.7.2.2 Build of Quantities

According to Portuguese legislation (Article 46º CCP), every Construction Document should include a complete list of the works that need to be undertaken and its quantity map.

This document is very important regarding the contractual relationships between the owner and the design team (Decreto-Lei n.º111-B/2018 de 31 de Agosto, 2018).

The content of this list, the measurements, and the quantities of each one of the elements and works belonging to the specialties of the Project Design, helps to create the map of quantities and to foresee the supply necessary to perform all the tasks required to construct the project.

This refers not only to the construction of the project itself but also to all those preliminary works that need to be performed in order to have full availability. These works need to be accompanied by a full description included in the technical specification deliverables. The main preparatory works are:

- Setting the site ready (vegetation removal, demolition, dismantling, among others).
- Safety works on/around the Site, regarding the well-being of the works and external stuff.
- Accesses to the site.

In terms of the quantity map itself, it can be submitted in two formats:

- Detailed quantity maps: containing the process of measurements in greater detail, in order to acquire a better understanding of the applied methodology, and to make easier the identification of mistakes or omissions.
- Summary quantity map: containing a summarized version of the quantity map, showing only the final results.

2.7.2.3 Material Specifications

Technical specifications refer to the prescriptions that define the techniques, procedures, materials, products or supplies in order to follow the owner's guidelines. It must be developed with succinct descriptions of the elements and in a common language to make it easier to understand.

The following elements should be explained in the list of specifications:

- Methodology and criteria to perform the measurements.
- Levels of quality or suitability of use.
- Security.
- Dimensions of the products and materials.

- Terminology.
- Symbols.
- Testing and test methods.
- Packaging, marking and labeling.
- Rules for the design and calculation of works.
- Construction techniques or methods.

2.7.2.4 Technical Drawings

The drawn elements describe in the best clear way the information of the contractor, including written annotations, description of the adopted materials as well as the components and constructive solutions, in a suitable scale.

These elements are an auxiliary support in the Construction Document Phase, to undertake precisely all the works that will be undertaken, reducing the risk of failure and, as consequence, the accomplishments of the deadlines and the project budget.

2.7.3 Project Monitoring

According to Decree-Law 111-B/2018, project monitoring aims to improve the expectations of the owner about granting the execution of what is arranged in the contract by protecting the established objectives.

There are two types of project monitoring:

- Project supervisor: based on the control and supervision of the project works and the registration of the monitoring in a work diary.
- Coordinator for safety and health: regarding the control of the safety and security of the staff and the Work.

2.7.3.1 Project Supervisor

The project supervisor is led by the owner and developed by a technician, or by a team depending on the complexity of the project, being necessary the identification of one of the members as a leader of the team.

One of the main considerations that should be taken into account is that the monitoring must not interfere in the normal development of the project, as well as not to compromise the responsibility and participation of the contractor.

The objectives pursued by the project supervisor are.

- Verify that the Project Design is implemented by the contractor as agreed with the owner.
- Verify with the contractor the prediction related to the ground conditions.
- Approval of the materials requirements.
- Control the execution processes and the way they are performed.
- Control the works deadlines.
- Control the occurrence of contracts or regulations infringements.
- Communication of any modification or notification introduced by the owner related to the Project Design performance to the contractor to get the corresponding approval.

2.7.3.2 Coordinator for Safety and Health

Safety coordination, during the execution of the works in projects with one or more companies involved, including the subcontractors, is mandatory according to the regulation Community Directive 92/57 / EEC of 24 June, by the designation of a coordinator for safety and health.

The coordinator is designated by the owner, starting as soon as the contractor is being designed. The coordinator has an important role in the risk prevention domain, by undertaking responsibilities like the following:

- Coordination and monitoring of the works of the Site by the contractor company and independent workers.
- Disclosure of the documentation.
- Setting up meetings with the stakeholders.
- Preparation of the prior notification of construction site.
- Technical validation of the safety and health plan for the work.

2.7.4 Prior Notification of Construction Site

According to legislation (Decreto-Lei n.º273/2003 de 29 de Outubro, 2003), the owner, even before the construction of the site, must elaborate and submit to the Authority for Working Conditions (AWC), a document that notifies the opening of the site if at least one of the following conditions verify:

- A total period of more than 30 days and at any time the simultaneous use of more than 20 workers;
- A total of more than 500 working days, corresponding to the sum of the days worked by each worker.

Even though the responsibility remains on the owner, the safety coordinator must advise during its elaboration.

The following information should be included in the document:

- Owner, contractor and execution company full identification.
- Monitoring members of the project and project safety coordinator full identification.
- Site full location.
- Nature of the work to be performed.
- Project and works established deadlines.
- An estimate of the maximum number of self-employed and independent workers who will be present simultaneously at the site, or the sum of the working days provided by each worker.
- Estimate of the companies and independent workers that will be operating at the Site.

The prior notification of construction site document must be submitted along with the following documents:

- Declaration assigned by the owner and the safety coordinator stating the work identification.

- ❖ Declaration assigned by the contractor and the safety coordinator stating the site identification and the scheduled deadlines.
- ❖ Owner´s notification to the Labor General Inspectorate (LGI), the safety coordinator and the contractor of any change within the next 48 hours.
- ❖ Owner's monthly notification to the LGI of the subcontractors on site.

There must be always a copy of this document and its updates available in an accessible place in the Site.

2.8 Project Design Closeout Phase

2.8.1 Phase description

Project Design Closeout is the last phase of a construction Project Design, whose objective, after completion of the Project Design or the different phases, is to formalize the owner's acceptance by reporting the results along the process (PMI, 2000).

In order to complete the Project Design or one of the phases, some activities must be undertaken (The Chartered Institute of Building, 2002):

- ❖ To issue partial certificates to transfer the responsibility of the works from the designers' team to the owner.
- ❖ To issue the Certificate of Practical Completion, that transfers the responsibility of the Project Design from the contractor to the owner.
- ❖ During the Defects Liability Period, the owner should report all the found mistakes and omissions and the contractor can carry out with the required modifications. After this period, the Final Certificate will be issued.

2.8.2 Planning and scheduling handover

The objective during this stage is, depending on the complexity and requirements of the project, to schedule all the necessary activities and protocols to assure a correct completion process (The Chartered Institute of Building, 2002).

All main aspects of completion and handover will generally cover the following activities:

- Shortlisting all identified errors and deficiencies.
- Monitoring and supervising completion and handover against the schedule.
- Post-handover monitoring and control plan.
- Maintenance post-handover program scheduled.
- Handover after all the inspections and approvals have been completed.
- Post-completion Project Design assessment plan and feedback from all the Project Design stakeholders.

2.8.3 Post- Project Design review

A post- Project Design review starts with a rectification period, which is the period between practical completion, when the client may take possession of some or all of the Project Design.

The post-Project Design review is undertaken once the Project Design has been transferred to the owner, in order to evaluate its performance based on what was agreed at the beginning of the process (P. Cartlidge, 2015). The elements that will work as a performance indicator are the following:

- Deliverables quality.
- Performance of the communication system between the different stakeholders.
- Project Design team's performance evaluation.
- Achievement of quality standards.
- Performance of the Health and Safety Plan.
- Claims and conflicts occurred.

2.8.4 Construction License

After all the Project Design requirements have been satisfied and verified, the owner must proceed with the licensing process of the Project Design to be able to move forward to the construction phase.

This process may present differences on the organisms involved depending on the complexity, type, and conditions of the project.

In case of a dam Project Design, which is the particular situation of this work, some of the portuguese organisms that should be considered in order to get the construction license are:

- National Civil Engineering Laboratory (NCEL)
- Portuguese Environment Agency (APA)
- National Emergency and Civil Protection Authority (NECPA)
- Working Conditions Authority (WCA)
- Directorate General of Energy and Geology (DGEG)
- National Power Network (NPN)

2.9 Conclusions

The bibliographic review is the first method of gathering information, based on the regulations and the technical specifications, serves as a first approach to make the final conclusions about the topic. In the following table, is remarked the key information of each one of the Design Project life cycle phases.

Design Project phase	**Key information**
Feasibility Program	❖ The promoter sets the basis to develop a new Project with the help of a Design team.
Programming Phase	❖ Document issued to the tenderers to elaborate a proposal. ❖ Key document that check the feasibility of the Design Project ❖ Several risk analysis determine the acceptance or rejection of the project
Schematic Design Phase	❖ Document issued by the Design team that develops the initial solution proposals. ❖ Low detail but stablishes the criteria and basic information of the technical solution ❖ A Project Design review may be required in order to clarify and complete the information.

Design Development Phase	❖ Iterate the technical solution to improve the planning of the Design Project. ❖ Include documents related to EIA, Construction and Demolition Waste Plan, Safety and Health Plan, Risk Identification Plan, Emergency Response Plan and Construction Permits.
Construction Document Phase	❖ Document that details the remaining information, which is necessary to the Design project construction ❖ A project supervisor and a coordinator for safety and health are designated. ❖ A Prior notification of construction site is submitted if necessary
Project Design Closeout Phase	❖ Document that formalizes the owner's acceptance of the Project Design ❖ Transference of the responsibility of the works from the designers' team to the owner.

Table 2-1.Key information of each one of the Design Project life cycle phases

There are many sources about any topic. On the one hand, regulations and technical specifications are the most trustable information and that should be taken into direct consideration. Some authors have about the same topic and each one of them contributes with subjective information, which means that it's very important to compare the information before implement it in our work, in order to make a trustable and objective research.

3 Research Methodology

3.1 Features of the research

Research is a process that consists of the scientific and systematic search of information about a topic so it could be summarized as a search for knowledge. According to Sabino (2002), research can be defined as an effort that is undertaken to solve a problem, of course, a problem of knowledge (Kothari, 2004)".

Making research involves defining and redefining problems, formulating hypotheses and suggesting solutions, collecting, organizing and analyzing data and making and testing conclusions in order to determine which ones adapt to the formulated hypothesis (G. Arias, 2012).

Researches are focused on different objectives such as:

- To become familiar with a phenomenon or face it from new perspectives.
- To portray more accurately an element or a situation.
- To determine the occurrence frequency of a phenomenon or its bound to other elements.
- To test a hypothesis.

Regardless of the type of research, there is a criterion that facilitates its development and quality. The most important criterion is a necessary and clear definition of the research objective, as well as the protocol or procedure to be followed by other researchers to continue with it.

Moreover, it is important to keep a faithful and coherent follow-up of the collected information, as well as an exhaustive data analysis to guarantee a reliable interpretation. In this way, we could conclude that good research is the one carried out systematically and logically.

The research can be carried out based on different purposes, namely the exploratory research, the descriptive research, and the explanatory research.

The exploratory research aims to examine a new question or phenomenon, of which there is hardly any information, so as to obtain preliminary ideas about it and to redefine the ideas about it for future deeper researches.

Similarly, descriptive research aims to frame an existing topic, in order to give response to the unknowns about it.

Finally, the explanatory research aims to explain a given phenomenon or element, including the elaboration, development and demonstration of the hypothesis (Neuman, 2014).

Depending on the nature, objectives or topic of the research, there are two approaches that can be adopted, the quantitative approach, and the qualitative approach (Basias & Pollalis, 2018).

The quantitative approach, as shown in Figure 12, studies a specific situation or phenomenon through statistics and the processing and analysis of data are done in numerical format.

Normally, this type of approach is adopted when there is a need to analyze and process large volumes of data to verify or test a hypothesis. It can be carried out through questioning of simple or closed questions.

One of the advantages of the quantitative approach is, given the numerical nature of the information, that it is not influenced by personal and subjective opinions.

Similarly, it allows to simplifying the process in case of large volumes of information, as well as an easy and quick comparison of the results.

Depending on the nature, objectives or topic of the research, there are two approaches that can be adopted, a quantitative approach and a qualitative approach.

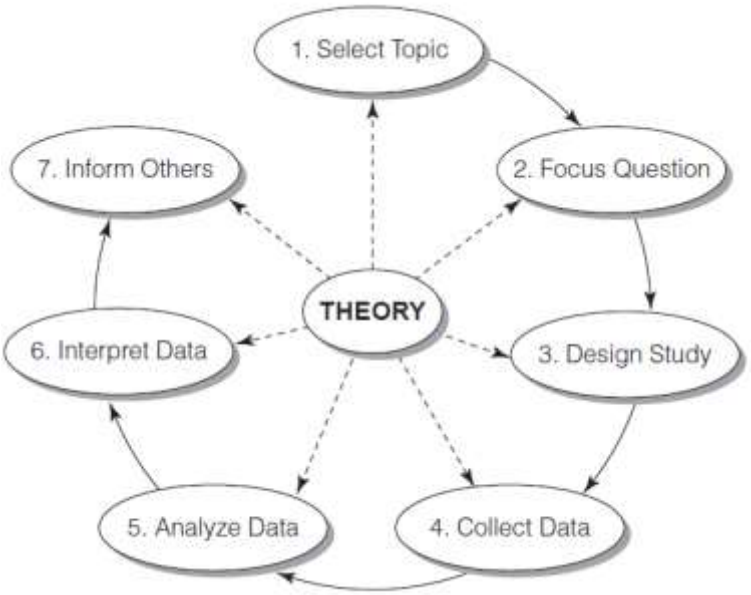

Figure 12. Quantitative research process

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The qualitative approach, as referred in Figure 13, faces a given phenomenon or situation through the analysis of experiences, relationships and behaviors without appealing to statistics or numerical processing.

It answers the questions of What? How? When? and Where? To sum up, it can be considered as a sequence of interpretive techniques, that aim to describe, solve and develop phenomena and situations.

This type of approach permits a better understanding of the topic to be addressed and a greater awareness of its nature and complexity.

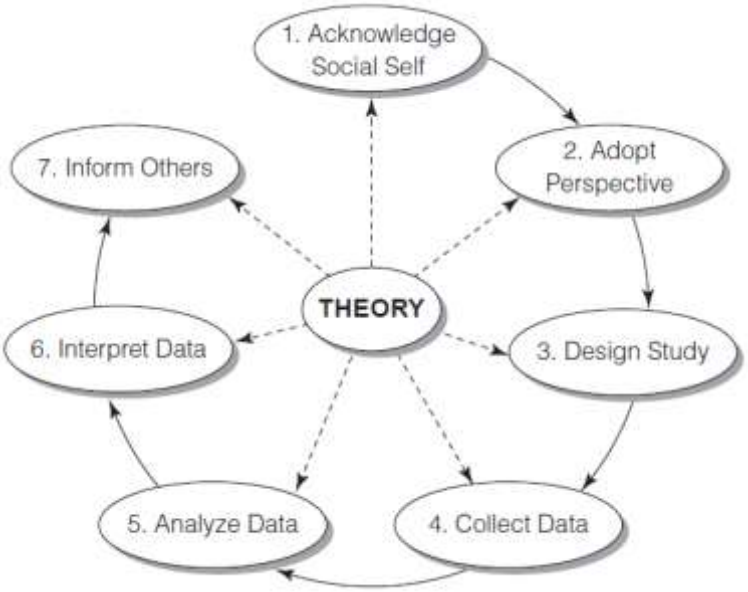

Figure 13. Qualitative research process

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The differences between both approaches, basically lie in the objectives, the data collecting method, the format of the obtained information and the flexibility in the investigation.

The qualitative approach offers greater flexibility to both the researcher and the interviewer, by formulating open questions that allow further development and more detail of the research. However, the qualitative research requires more caution during their application which depends on the interviews and specially on the experience of the researchers.

On the other hand, the quantitative approach, based on simpler and standardized questions, has a condition of inflexibility which is more objective and without high risk to fail.

3.2 Research methodology used

3.2.1 Particularities of research methodology

A Research methodology is the systematic way to develop a research, stating all the steps followed by the researcher and the adopted logic.

It is very important to know all the assumptions and criteria in each one of the available techniques in order to choose the most suitable one to be applied for the resolution of a specific problem or situation.

Once stated the objective of the research, the available data and the unknowns, it will be necessary to choose the best methodology. Frequently, research methodologies can be classified into three groups.

The first group includes those methods oriented to the collection of data, in the situations where the available information is not enough to reach a solution. Within this group, we can find the analysis of historical data or the documentary consultation.

The second group includes the methods and techniques used to establish relationships between the collected data and the unknowns of our research. Within this group, we can find the observation, the case studies, and the interviews.

The third group includes the methods used to evaluate the accuracy of the obtained results. Within this group, we can find the laboratory analyzes.

3.2.2 Bibliographic review

In order to start a research, it is important to justify how it will serve to improve the existing knowledge on a given topic and clearly establish the objectives.

Subsequently, a bibliographic review will constitute the basis of the research, including the analysis, and definition of all the concepts, hypotheses, and antecedents. If this review is carried out exhaustively, the research will have a solid basis to be developed.

To establish an appropriate theoretical framework, the clearance of the topic of the research is fundamental to collect all the existing bibliography on the topic under study. In this case, the focus of the research is on dam construction Project Design, which are completely different from building or renovation Project Design, in terms of regulations and deliverables required.

Once the topic is clearly defined, as shown in Figure 14, a critical reading and a review are carried out to include in our research only reliable and quality information and, thus, be able to elaborate hypotheses that will be the starting point of our research (Esquirol-Caussa, Sanchez-Aldeguer, & Dalmau Santamaria, 2017).

Figure 14. Bibliography review process

The first stage of the bibliographic review on the management of construction Project Design, consists of identifying the different phases, their participants and the provided documents in each one of the situations and their purposes from the conception of the Project Design to the construction of the Project. This information can be collected from two sources.

On the one hand, there are many authors who are specialized on the field and who made their own researches providing their objective point of view about how this Project Design works and giving a comparison against the other type of construction Project Design.

On the other hand, there are authors who were involved personally in Project Design of this kind, and they can provide a deeper point on view based on the personal experience, despite the fact that in Portugal there are not too many construction Project Design related to irrigation dams regarding its magnitude.

There must be taken also into consideration, the current regulation and technical advises by the different agencies and competent authorities in matters of development, organization, and management of construction Project Design.

Regarding dams and hydraulic projects, there is a strict regulation due to the high impact that they have over the population and the economy. This translates into certificates, licenses and permissions that must be taken into account to develop this kind of Project Designs.

The bibliographical review aims to satisfy objectives and to respond to multiple questions and hypotheses related to the topic of this work.

Thus, it is verified that there is certain flexibility when it comes to hierarchizing the processes, establishing the different phases of the Project Designs and preparing and delivering the different documents.

Coming back to the topic of this research, the bibliographic research helped to develop a main idea about the management of construction Project Designs in terms of:

- Stakeholders and the hierarchy of the development process from the conception to the Construction Document Phase.
- The life cycle of a dam construction Project Design, defining the different phases in which they are divided (Feasibility Phase, Programming Phase, Schematic Design Phase, Design Development Phase, Construction Document Phase and Project Closeout).
- Basic deliverables that are required in the construction Project Design, that must be submitted during the different phases in order to move on into the following phase (EIA, CDW, etc.).
- EU directives and national regulations that apply to general construction projects.

On the opposite, the bibliographic review doesn't reveal so much information about the following topics, more specialized in the focus of our research:

- Deliverables concerning the construction of dams and hydraulics Project Design and their deadlines.
- Duties and responsibilities of the different stakeholders who participate in the Project Design.

- EU directives and national regulations that define the framework of this type of Project Designs, such as, the licenses required to the design teams, the certificates that must be acquired or the constraints that must be taken into account.

It is due to these factors, for which the bibliographical review, does not allow to satisfy all the objectives of this work, being necessary to resort other research methods, which would allow to complement, refute and extend the collected information so far, in order to guarantee a better understanding and reliability of the results.

3.2.3 Case study implementation

The case study is a research method based on a qualitative approach that focuses on a specific topic of study that, in a subjective and empirical way, tests the hypotheses to and the objectives of the research to be accomplished (Benbasat, Goldstein, & Mead, 1987).

A case study requires some antecedents, such as a defined topic, clear objectives, a firm bibliographic base, questionnaires for data collection and a guideline to be followed in order to prepare the case study (Yin, 2003).

In this kind of method, the object of study is analyzed and treated thoroughly, to deeply know the conditioning and factors that involve it, allowing to enrich the existing knowledge on a topic.

There are several phases involved in a case study. Firstly, there is the recognition and determination of the state of a given situation or phenomenon that is going to become the object of our research. Following, we can find the phases of data collection and examination of that event. Finally, we have the phase of diagnosis and results analysis, to identify the factors and conditionings of the topic.

This method also has restrictions. On the one hand, the case studies are not fully comparable, since they all include a group of particularities. In addition, this method involves a large investment in time and resources, so, for this reason, it is usually limited to a reduced number of case studies to avoid an unmanageable volume of information.

The data sources used can be very different ones form the others, being the most common source the documentary consultation, interviews, direct observation, participant observation or physical elements.

All these sources of information, as shown in Table 3-1 and Table 3-2, have their strengths and weaknesses, which means than can they can be applied simultaneously in order to get a more complete and trustable research (Yin, 2003).

Source of Evidence	Strengths
Documentation	❖ Stable - Can be reviewed repeatedly ❖ Unobtrusive – Not created as a result of the case study ❖ Exact – Contains exact names, references, and details of an event. ❖ Broad coverage – Long span of time, many events and many settings.
Archival Records	❖ [Same as above for documentation]. ❖ Precise and quantitative.
Interviews	❖ Targeted – Focuses directly on case study topic. ❖ Insightful – provides perceived casual inferences
Direct Observations	❖ Reality – Covers events in real time. ❖ Contextual – Cover context of event
Participant Observations	❖ [Same as above for direct observations]. ❖ Insightful into interpersonal behavior and motives.
Physical Artefacts	❖ Insightful into cultural features. ❖ Insightful into technical operations.

Table 3-1Weaknesses and Strengths of the sources of information.

Source of Evidence	Weaknesses
Documentation	❖ Retrievability – Can be low. ❖ Biased selectivity – If collection is incomplete. ❖ Reporting bias – Reflects (unknown) bias of author. ❖ Access – Maybe deliberately blocked.
Archival Records	❖ [Same as above for documentation]. ❖ Accessibility due to privacy reasons.
Interviews	❖ Blas due to poorly constructed questions. ❖ Response bias. ❖ Inaccuracies due to poor recall. ❖ Reflexivity – interviewee gives what interviewer want to hear.
Direct Observations	❖ Time-consuming. ❖ Selectivity – unless broad coverage. ❖ Reflexivity - event may proceed differently because it is being observed. ❖ Cost – hours needed by human observers.
Participant Observations	❖ [Same as above for direct observations]. ❖ Blas due to investigator's manipulations of events.
Physical Artefacts	❖ Selectivity. ❖ Availability.

Table 3-2Weaknesses and Strengths of the sources of information.

In this particular research, that are not frequently undertaken, was resorted to the method of a single situation case study. This method, although it is not the most recommended because normally the more case studies the wider is the approach of the research, allows to obtain a deeper analysis of the study case in question.

The objective of this method in this case study, is to give answer to those unknowns that were not solved in the bibliographic review, such as to identify the deliverables concerning the construction of dams and hydraulics Project Design and their deadlines.

This method also defines the duties and responsibilities of the different stakeholders who participate in the Project Design or create a specific framework for dam construction Project Design based on the EU directives and national regulations, such as, the licenses required to the design teams, the certificates that must be acquired or the constraints that must be taken into account.

This single situation case study involves two sources of data, the documentary review of a dam construction Project Design complemented by an interview supported by a questionnaire to the technicians involved in the Project Design.

These sources were selected thanks to the access to one irrigation dam construction Project Design in Portugal, which was in execution process, so that could give answer to all our questions and to refute all the information collected in the bibliographic review.

The Project Design follows the current regulation, but it has been shown in many situations that some details are unclear or omitted in the legislation.

The research preview that the Project Design consulted does not apply in the following situations:

- Key points and decisions that change for the different phases of the Project Design.
- Internal interventions among different stakeholders.
- Follow-up of the process in various entities being licensed and opinions.
- Tightest form of procurement and potential competitors to the Project Design.
- Internal decision for elimination of some phases of the Project Design, especially at the moment when the designer is defined.

- Expropriation procedures.
- Public consultations.

Some of these technical and management issues are expected to have no response in the Project Design. In this way, the interviews, especially with the designer and Project Design coordinator, will give a different point of view of the process and will make clearer the management development of that irrigation dam construction Project Design.

However, there are some difficulties that may result from the interview, and the researcher must be prepared for it (Yin, 2003).

The interviewee can give a very technical or theoretical lesson about the Project Design to the interviewer, and it may be difficult to answer directly to the questionnaire. It may happen that in Yes/No questions, there are comments about the questions that may be important but it can lead to a loss of time.

In this situation, the interviewer should have a clear knowledge of the issues and if possible, make the comments to link with other issues. In this case, the interview is supported by a questionnaire that is followed by the interviewer with the interviewee, serving as a script.

This questionnaire covers questions about subjects that the Project Design did not respond to and which are important to know the kind of management undertaken in this kind of Project Designs.

Thus, the methodology applied in this case study is considered to be more complete, comprehensive and with a cohesive structure, following a qualitative orientation. The two types of resources used, complement each other, in the same way, in the use of the unique method of this case study, studying in a more approximate, exhaustive and complete, the management procedures addressed in the various phases of this Project Design.

The results from the case study in this research, are expected to be more topic-oriented and proximate to a real situation than the results from the bibliographic review, but also not enough to develop a valid build of knowledge, based on the reduced number of sources available, which will require the application of some other research methods.

4 Case Study

4.1 Case Study Framework

The documentary consultation is usually one of the most relevant sources of information in the case studies, because it can be based on letters, agendas, administrative documents, progress reports, internal documents, formal studies , "in situ" evaluations or even newspaper articles (Yin, 2003).

The main use of this documentation is to refute, complete and compare information from other sources, including the bibliographic review. This source offers great flexibility when it comes to the gathering of information, adapting to the researcher needs.

The data obtained from historical records can be presented in different formats, such as reports related to the organization, maps of activities and quantities, geographical, geological or hydrological studies. The main handicap in order to compare study cases are the differences and particularities between them.

Regarding the topic of this research, the construction of an irrigation dam, the main problem was the reduced number of projects that are available in the country, because of the dimension and resources that it implies, being one of the most complex works in the construction industry.

Thus, in order to be able to develop this research, the single case study method was adopted, due to the fact that there was a dam being constructed in the north of Portugal.

This dam was already in the construction phase of the project, which meant that the Project Design had been elaborated and approved, becoming the perfect scenario to refute the information collected during the bibliographic review and to give answer to all the unknowns.

The case study has been developed in two stages, being the first stage based on the documentary consultation of the Project Design provided by the owner team. The second stage is based on the interview with the designing company stakeholders who participated in the elaboration of that Project Design.

4.2 Design Documentation Consulting

4.2.1 Context of the documents of the Dam's Project Design

The documentation consulting is a process highly attached to the availability of construction projects related to the topic in study, which was limited in the particular situation of this research. However, the existence of a dam construction, whose Project Design had already been approved, allows to have access to trustable and quality information, especially when they are supported by the designer team.

The process of getting access to the Project Design information, emphasizing on the academic purposes, started with a formal request via e-mail to the director of the company who was in charge of the elaboration.

After receiving acceptation of the request, the information related to the Project Design was sent to analyze and review the information that was needed to complete the research.

The construction project consists in the construction of a gravity dam made out of concrete based on a multiple objectives exploitation in the Ribeira de Rebordãos (Bragança).

The main goal of this project is to serve as a deposit of water for crop irrigation, the main economic activity of the region. As a complementary objective, it was also considered the production of electricity as well as serving as an emergency water deposit in case of forest fire.

The advantages of this type of construction projects lie in the economic and social impact of dams in the regions where they are located, since they meet important needs, such as water supply, production of electricity, employment creation, among others.

However, some disadvantages should also be considered, related to the execution, such as the technical complexity due to the specialized equipment that is required and the precision of all the calculations to avoid risks from a structural and safety point of view.

Since there are populations nearby the dam, it was necessary to invest a lot of resources in studies and control in order to grant safety.

One of the major constraints of the dam construction, which is worth mentioning, is the location, implying a group of factors that determine the success of the work, such as soil movement, accesses control, safety issues, among others.

The dam, as shown in Figure 15, is located in the Freguesia de Rebordãos, in the course of the Rebordãos river, tributary of Fervença river. This location presents as an advantage the existence of an access, a road that can be easily used to develop the works to construct the dam.

Figure 15. Location of the dam construction site

Regarding the implementation of an electricity generation system, a technical and economic feasibility study was undertaken in order to check its viability.

This kind of Project Design requires an extensive documentary base, considering all the aspects to be applied for its execution from a technical, economic and safety point of view.

The Rebordãos dam construction Project Design, due to EU financial issues, does not follow the theory of the Project Design management, because all the documentary base revolves around two phases, the Schematic Design Phase and the Construction Document Phase.

The Schematic Design Phase is constituted by the technical-financial feasibility study, where it is explained the main characteristics of the hydraulic situation, such as the hydrological study and the hydric resources availability.

The study also describes and analyzes not only the feasibility of the main objective, the crops irrigation, but the complementary objective, the production of electricity, being both profitable for the client.

On the other hand, the Construction Document Phase develops a constructive solution and all the required documents to satisfy the Project Design objectives.

The function of these documents is to reduce the degree of uncertainty and consider all the surrounding factors of the Project Design.

The Construction Document Phase is based on the following documents:

- Geological, geotechnical and hydrogeological study.
- Topographic study.
- Observation plan.
- Environmental Impact Assessment (EIA).
- Internal Emergency Response Plan (IERP).

4.2.2 Project Design Documentary Consultation

Once the goals of the Project Design had been stated, and, out of courtesy of the responsible company, all the deliverables from the Project Design were provided, it was possible to start the documentary consultation to help to refute and complete the information obtained in the bibliographic review.

4.2.2.1 Feasibility Study

This deliverable analyzes the technical-economic feasibility of the construction of the dam in Ribera de Rebordãos as a system for crops irrigation and, as a complementary objective, the production of electric energy as a complementary objective.

In order to meet these objectives, it was very important to evaluate the hydric resources availability, in terms of quantifying the daily average flow and the maximum flow.

This can be done directly through the installation of hydrometric stations, but in this situation, due to the high costs and the complexity of their implementation, flow rates were studied indirectly by extrapolation of the of a similar basin.

Following the technical study, the construction system is studied to ensure the profitable production of electricity, taking into account the necessary hydric conditions and the needs of flow versus the available flow.

Finally, once the technical feasibility was verified, the economic study was developed, taking into account the costs of execution, maintenance and especially the return period of the investment, obtaining positive feedback.

4.2.2.2 Geological, geotechnical, hydrogeological and rainfall study.

The geological-geotechnical-hydrological study aims to characterize the rock mass that will serve as a foundation of the projected dam. In order to carry out this study, mechanical rotation soundings with sample collection and Lugeon permeability tests were completed.

This kind of tests consists in the injection of water at a certain pressure in a section of a perforation made in the rock mass during a stablished period of time, which allows to calculate the permeability.

These results of the study proved the rocky mass is competent and homogeneous.

In the particular situation of a dam, it is important to know the rainfall distribution on the basin and to know its distribution, frequency and intensity throughout the year. The method of measurement used, besides the study of the history of precipitation, was the installation of rainfall stations in strategic points of the basin and to calculate its distribution weighted by the Method of Thiessen.

4.2.2.3 Topographic study.

In order to serve as a base for the implementation of the dam, its basin, the ducts for the cargo chamber and watering, and a topographic survey was carried out.

Although the access to some of the sites was hampered by the presence of vegetation and crops, the study was developed without incidences. The data was collected with precision GPS equipment and tablet pc by means of visual inspection of the elements in the field.

4.2.2.4 Observation plan.

The observation plan is mainly aimed at structural safety control during the initialization, the first exploration period, usually 5 years, and the subsequent exploration periods.

For each one of these phases, the observation plan considers the major accident scenarios, for example, rapid dumps, overflows or earthquakes.

To achieve this consideration, the following resources are available:

- Visual inspection.
- Installation of observation devices.
- Frequent readings of the observation devices.
- Collection and processing of the information.
- Qualification of the personnel in charge of the installation and application of the observation system.

Telecommunication facilities are planned to be installed in the dam allowing remote control.

4.2.2.5 Environmental Impact Assessment (EIA).

The purpose of the EIA was to characterize the state of the environment in the area, as well as to evaluate the possible positive and negative impacts resulting from the construction, exploration and deactivation phases of the project. It is intended to indicate the measures for the minimization / compensation of the negative impacts and the measures that enhance the positive impacts, as well as to define the environmental monitoring plan to be implemented.

The factors that were considered in the research were:

- Geology, geomorphology and mineral resources.
- Underground hydric resources.
- Surface water resources.
- Air quality.
- Noise production.
- Ecological systems.

- Flora and Fauna.
- Soil exploitation.
- Cultural heritage.
- Economic and social issues.
- Health care.
- Landscape.
- Weather

The analysis of the impacts allowed to verify that the project does not present significant impacts. The main negative impacts are on the ecological systems, soil, economic and social issues and landscape factors. Minimization measures were defined to reduce the impacts identified.

4.2.2.6 Internal Emergency Response Plan (IERP).

The Intern Emergency Plan develops the contingency plans that prevent, monitor and respond to any emergency in the dam, to protect the lives and property of the people living in the downstream valleys.

The study of the breakdown of the dam was carried out to determine the areas potentially affected by the propagation of the flood wave resulting from an eventual collapse of the dam.

After analyzing the results, an accident protocol was developed, including the alert and warning systems to alert the population and the authorities.

4.2.3 Documentary Consultation Conclusions

This chapter allowed to get to know one of the multiple available sources of information to develop research and, thus, to obtain more accurate and reliable results in order to make the final conclusions.

Although the case study can be conditioned by the availability and access to the information, it provided a large volume of information. Therefore, it is considered one of the most valuable data sources in the development of research.

Regarding the dam construction Project Design, as shown in Table 4.1, the documentary consultation allowed to acquire the real perspective of a real Project Design situation and, moreover, to partially refute the information obtained during the bibliographic review.

The documents provided by the company were so complete and trustable that it was possible to get closer to the accomplishments of the research objectives, like explaining the development of a dam construction real Project Design and how it is influenced by the current regulation related to the hydraulic projects.

The consultation provides a deeper approach to the tendering process, the content of the deliverables along the life cycle of the Project Design. It also made possible to extend the information related to the responsibilities and duties of the different members involved in the Project Design, both the design team and the client.

The Project Design also extends the information related to the specialized deliverables required in dam Project Design, such as Project Design review, rainfall study or a stricter EIA in terms of risks analysis and mitigation measures, always supported by the regulation of this construction sector.

Project Design phase	Deliverables	Provided Information
Feasibility Phase	Feasibility study	❖ Life cycle of a construction Project Design, in terms of the deadlines and phases required to be done to accomplish the Project Design objectives. ❖ Tendering process and licensing requirements that the potential companies should apply for in order to get the Project Design assignment. ❖ Specialized regulation applied to hydraulic construction Project Design, because it present particularities on the works needed to be done and constraints that must be taken under consideration. ❖ Division of responsibilities among all the stakeholders of the Project Design (Client, designer's team), which allow the perfect synergy to achieve the stablished objectives. ❖ Content and structure of the particular deliverables in a dam construction Project Design in order to cover all the risks and information to reduce to the minimum the risk of delay, accidents and extra costs.
Construction Document Phase	Geological Study Geotechnical Study Hydrogeological Study. Topographic Study. Observation Plan. EIA IERP	

Table 4-1. Information provided by the documentary consultation.

However, the fact that the dam construction Project Design was only based on two of all the Project Design phases identified along the bibliographic review, complicated the accomplishment of one of the research objectives, to fully explain the whole Project Design life cycle.

By undertaken only the Schematic Design Phase and Construction Document Phase, there are some details related to the document elaboration process, their deadlines and the acceptance decisions, that cannot be approached exclusively through the documentary consultation, being necessary to resort to other research methods to get more detailed results.

In Table 4.2, is shown the status of the research after the documentary consultations, and all the unknowns still remaining and that need to be satisfied.

Project Design Phase	Phase Particularities	Deliverables	Unknowns
A -Feasibility Phase	❖ The promoter sets the basis to develop a new Project with the help of a Design team.	Not submitted	❖ A-1. In this Project Design, was it considered the Feasibility Phase? ❖ A-2. Was the Feasibility Phase presented by the Owner of work delivered to the designer under acceptable technical? ❖ A-3. What was the content of the Feasibility Phase? ❖ A-4. Was it required by the client any document, guarantee or specification to be attended in the Project Design?

Project Design Phase	**Phase Particularities**	**Deliverables**	**Unknowns**
B-Programming Phase	❖ Document issued to the tenderers to elaborate a proposal. ❖ Key document that check the feasibility of the Design Project ❖ Several risk analysis determine the acceptance or rejection of the project.	Not Submitted	❖ B-1. In this Project, was it considered the Programming Phase? ❖ B-2. What was the content included in the Programming Phase? ❖ B-3. Where considered any other alternative technical solutions posed as potential hypotheses? ❖ B-4. ¿What was the deadline to deliver the Programming Phase? ❖ B-5. What was the established criteria by the Owner of the work to proceed with the completion of the Programming Phase and the transition to the Schematic Design Phase?

Project Design Phase	Phase Particularities	Deliverables	Unknowns
C - Schematic Design Phase	❖ Document issued by the Design team that develops the initial solution proposals. ❖ Low detail but stablishes the criteria and basic information of the technical solution ❖ A Project Design review may be required in order to clarify and complete the information.	Feasibility Study	❖ C-1. Is there any document that has been considered and that conditioned the technical solutions submitted? ❖ C-2. Was it elaborated a Work Breakdown Structure (WBS)? ❖ C-3. What is the estimated budget of the work? ❖ C-4. Was it necessary to undertake a Project Design review during the Schematic Design Phase? ❖ C-5. ¿What was the deadline to deliver the Schematic Design Phase? ❖ C-6. What was the established criteria by the Owner of the work to proceed with the completion of the Schematic Design Phase and the transition to the Design Development Phase?

Project Design Phase	Phase Particularities	Deliverables	Unknowns
D - Design Development Phase	❖ Iterate the technical solution to improve the planning of the Design Project. ❖ Include documents related to EIA, Construction and Demolition Waste Plan, Safety and Health Plan, Risk Identification Plan, Emergency Response Plan and Construction Permits.	Not Submitted	❖ D-1. In this Project Design, was it considered the Design Development Phase? ❖ D-2. What was the content of the Design Development Phase? ❖ D-3. What were the stages in the licensing process of the works? ❖ D-4. ¿What was the deadline to deliver the Design Development Phase? ❖ D-5. What was the established criteria by the Owner of the work to proceed with the completion of the Design Development Phase and the transition to the Construction Document Phase?

Project Design Phase	Phase Particularities	Deliverables	Unknowns
E- Construction Document Phase	❖ Document that details the remaining information, which is necessary to the Design project construction ❖ A project supervisor and a coordinator for safety and health are designated. ❖ A Prior notification of construction site is submitted if necessary	Geological Study Geotechnical Study Hydrogeological Study. Topographic Study. Observation Plan. EIA IERP	❖ E-1. What was the content of the contract dossier? ❖ E-2. ¿What was the deadline to deliver the Construction Document Phase? ❖ E-3. What was the established criteria by the Owner of the work to proceed with the completion of the Construction Document Phase and the transition to the Project Closeout Phase?

Project Design Phase	Phase Particularities	Deliverables	Unknowns
F - Project Closeout	❖ Document that formalizes the owner's acceptance of the Project Design ❖ Transference of the responsibility of the works from the designers' team to the owner.	Not submitted	❖ F-1. How was developed the process of Project Closeout? ❖ F-2. Was there a deadline to receive the licensing permission approval?

Table 4-2. Status of the Research after Documentary Consultation

Thus, and considering the specifications and restraints that define the current Project Design, the interview method was adopted to continue with the research, for it has a deeper and subjective approach, allowing, from a source directly related to the case study, to obtain all the remaining information that could not be obtained from the documentary consultation and accomplish all the stablished objectives of this research.

4.3 Dam Project Design Interview

4.3.1 Introduction

Interviews are guided conversations rather than structured questionnaires, which means that they have a more fluid condition than if they were a rigid line of questions (Yin, 2003).

The interview process implies carrying out two tasks, following the pre-established script and formulating the questions impartially so as not to condition the answer of the interviewee.

Thus, the interviews of the case studies have to be open-ended, considering also the opinion of the interviewee. The interviewee can also suggest other people to be interviewed who can be valid source of information.

There are other types of interview that have time limitations. In this case, the interview is done in the similar way to the interviewee than the model explained before, but aiming to carry out in a structured way, the pre-established questions, suppressing the personal opinion of the interviewee.

The third type of interview would be a formal questionnaire, with greater structured nature, which could even be used in a quantitative approach.

To sum up, the interviews are a source of essential information, because they provide the human factor and a personal opinion that provides new and valuable perspectives in our work of study.

4.3.2 Project Design Interview Development

This part of the investigation develops the interview process along with the participants in the area of execution of construction Project Designs and, particularly, of irrigation dam projects, in order to analyze aspects related to the procedure of preparing the deliverables and the deadlines that were not answered during the documentary consultation phase.

The interviews were carried out according to the 3 following phases:

- Preparation of the interview.
- Content of the interview.
- Results analysis.

4.3.2.1 Preparation of the interview

As a consequence of the limited number of dam construction projects, and, therefore, the number of companies specialized in this area, it was taken the decision of contacting the Project Design team responsible for the dam Project Design in Ribeira de Rebordãos.

The purpose of this contact was to conduct an interview with the team members who took part of the Project Design in order to complete the information gathered during the previous stages of bibliographic review and documentary consultation.

Thus, the design company was contacted by telephone and later via email. During the telephone contact, the objective of the study was explained, as well as the guarantee of confidentiality for the given answers and opinions, as well as the acknowledgments for the collaboration carried out.

Via e-mail, the interview proposal was sent in order to obtain approval from the consulted company and any modification that could be considered.

The Professor Engineer José Ferreira Lemos, as president of the multidisciplinary consulting company Ferreira Lemos Engenharia, which is responsible for the construction Project Design of the dam in Ribeira de Rebordãos, offered selflessly to help and contribute as much as he could in this work, agreeing to participate in the interview.

The interview, in order to grant the convenience of the participants involved, was held in person at the company's headquarters in the city of Porto (Portugal), where all the issues previously discussed were addressed.

This interview served to set clear concepts related to the tendering process, the needed documents and their delivery, as well as the phases that compounded the process.

4.3.2.2 Content of the interview

In this research, in order to complete the information that remained unanswered after the bibliographic review and the documentary consultation, was taken into consideration the submission of an interview.

The development of the questionnaire of the interview, took as a model the Table 4.2 in the Chapter 4.2.3 of this research, which shows the unknowns that still need to be satisfied to achieve the initial objectives.

The questionnaire, which is in the Appendix I1, contains 49 questions numbered from 1 to 49 organized in 7 blocks corresponding to general questions block and 6 blocks corresponding to the phases of a construction Project Design.

The questions are mainly open questions, except 5 "Yes/No" questions and 5 "Choose a temporary range" question.

In a theoretical situation, all the questions would be answered, but in any case, there are questions conditioned to the submission or not of any of the Project Design phases, thus, if it was not done, that block remains unanswered.

4.3.2.3 Results analysis

The data collected from the interview was extensive, because the interviewee gave extra information in those open questions that were more susceptible to be developed, which allowed to get a deeper approach that were not the main point of the questionnaire, like the details of the tendering process, technical information related to the constructive solutions considered or the environmental considerations that they had to deal with.

Given the results, it was necessary to undertake an analysis in a qualitative way to filter the information that strictly attached to the topic of the research and with the most objective nature.

Once the information was filtered, it was compared to the information previously collected during the bibliographic review and documentary consultation, in order to refute the research information and modify the perspective from where it was considered, acquiring a more focused approach on the particularities and processes involved in this type of Project Designs.

This Project Design, given the time restraints in terms of EU funding process and the complexity of the Project Design, consists of the Feasibility Phase, based on the technic and economic feasibility study, and the Construction Document Phase.

Thus, the standard life cycle of a construction project considered in the bibliographic review cannot be refuted with this case study.

As conclusions of the questionnaire, reflected in Table 4.3, can be extracted the life cycle of a real situation of a dam construction Project Design, showing the timings and deadlines of all the processes involved, and where the delays and errors may occur.

Unknowns	Answer	Conclusion
❖ A-1. In this Project Design, was it considered the Feasibility Phase? ❖ A-2. Was the Feasibility Phase presented by the Owner of work delivered to the designer under acceptable technical? ❖ A-3. What was the content of the Feasibility Phase? ❖ A-4. Was it required by the client any document, guarantee or specification to be attended in the Project Design?	❖ These questions remained unanswered because the Feasibility Phase was not submitted	❖ The Feasibility Phase, under particular conditions can be overpassed. Besides, the feasibility study was taken into consideration in the Schematic Design Phase

Unknowns	Answer	Conclusion
❖ B-1. In this Project, was it considered the Programming Phase? ❖ B-2. What was the content included in the Programming Phase? ❖ B-3. Where considered any other alternative technical solutions posed as potential hypotheses? ❖ B-4. ¿What was the deadline to deliver the Programming Phase? ❖ B-5. What was the established criteria by the Owner of the work to proceed with the completion of the Programming Phase and the transition to the Schematic Design Phase?	❖ These questions remained unanswered because the Programming Phase was not submitted	❖ The Programming Phase, under particular conditions can be overpassed.

Unknowns	Answer	Conclusion
❖ C-1. Is there any document that has been considered and that conditioned the technical solutions submitted? ❖ C-2. Was it elaborated a Work Breakdown Structure (WBS)? ❖ C-3. What is the estimated budget of the work? ❖ C-4. Was it necessary to undertake a Project Design review during the Schematic Design Phase? ❖ C-5. ¿What was the deadline to deliver the Schematic Design Phase? ❖ C-6. What was the established criteria by the Owner of the work to proceed with the completion of the Schematic Design Phase and the transition to the Design Development Phase?	❖ C-1. No, there were not special restrains that conditioned the technical solution. ❖ C-2. Yes, but only in the Construction Document Phase. ❖ C-3. Approx. 3.600.000€. ❖ C-4. Not necessary, because it is not included in Class 5 activities. ❖ C-5. 3-6 Months. ❖ C-6. Prove of Feasibility	❖ The schematic design phase represented the first milestone of the Design Project, which was simplified only to the feasibility study that allowed to move on with the development of the following phases. ❖ It can be extracted that the structure of this phase is not standard, but can be adapted according to the particularities of each project.

Unknowns	Answer	Conclusion
❖ D-1. In this Project Design, was it considered the Design Development Phase? ❖ D-2. What was the content of the Design Development Phase? ❖ D-3. What were the stages in the licensing process of the works? ❖ D-4. ¿What was the deadline to deliver the Design Development Phase? ❖ D-5. What was the established criteria by the Owner of the work to proceed with the completion of the Design Development Phase and the transition to the Construction Document Phase?	❖ These questions remained unanswered because Schematic Design Phase was not submitted	❖ The Schematic Design Phase, under particular conditions can be overpassed.

Unknowns	Answer	Conclusion
❖ E-1. What was the content of the contract dossier? ❖ E-2. ¿What was the deadline to deliver the Construction Document Phase? ❖ E-3. What was the established criteria by the Owner of the work to proceed with the completion of the Construction Document Phase and the transition to the Project Closeout Phase?	❖ E-1. Geological Study Geotechnical Study Hydrogeological Study. Topographic Study. Observation Plan. EIA IERP ❖ E-2. >6 Months ❖ E-3. The considered criteria by the promoter.	❖ The Construction Document Phase, as can be extracted from Table 4.4, constitutes the core of the Project Design, because is where most of the deliverables are provided and where the construction process is defined. ❖ This phase reflects the real content of a dam construction Project Design.

Table 4-3. Conclusions of the questionnaire

These questions prove the complexity of submitting an interview due to all the factors that restraint the results, such as the project experience and its magnitude, the role of the interviewee on the Project Design and the personal information processing skill.

This questionnaire was used to clarify if the objectives that were not accomplished during the bibliographic review and documentary consultation were finally accomplished thanks to this interview. The rest of the answers, included in Appendix I2, refute this idea, giving more criteria to determine the conclusions of this research.

4.4 Case Study Conclusions

This chapter allowed to get to know the information gathering method of the case study, turning out to be a very useful way to complete and increase the information about a given topic, because it allows a direct approach thanks to the interaction with the people involved in the construction Project Design, who can provide their opinion and thoughts about it, which would be impossible to get from any other of the methods to collect information.

The method applied in this research given the circumstances, only allows to get the perspective from one sample, which is not the most positive situation, but despite this situation, it could be refuted the life cycle of a real Project Design and how the content of the deliverables is managed.

On the other hand, the fact of the limited dam construction availability makes the information collecting method, not the most suitable one, reaching a greater value when there is a higher number of Project Designs available.

5 Final Conclusions

5.1 Introduction

This last chapter aims to present the final conclusions about the research that has been undertaken. The structure of this chapter is organized as follows:

- Main conclusions and objectives achievement.
- Research limitations.
- Research contributions.
- Further development.

5.2 Main conclusions and objectives achievement

After analyzing the initial objectives that were established in this research, it can be determined that they were partially accomplished.

The first objective consisted of understanding the management process throughout all its phases based on the regulations and bibliographic reviews from different authors.

It can be concluded that, although regulations and technical specifications are irrefutable sources of information, they must be taken into direct consideration in any research. The bibliographic review presents a wide range of authors, and each one of them provides their own subjective ideas and methods, which turns the results less trustworthy and subjective.

In addition, owing to the documentary consultation, new regulation related to irrigation dams and hydraulics construction Project Designs were considered, which defined in a clearer way the framework of the process and all the legal aspects that were involved.

On the other hand, there is are a huge variety when it comes to hierarchizing, defining the Project Design phases and delivering the required documents.

Thus, it can be concluded that the bibliographic review itself is not enough to achieve all the objectives of this research. Therefore, it turns out to be necessary to look for other information gathering methods in order to complement and check the available information as well as to guarantee a better understanding and reliability.

It is worth mentioning, that in some Project Designs not all the life cycle phases are undertaken because they serve as checkpoints in order to reduce risks on the deliverables, protocols or constraints, specially related to the initial phases of the Project Design. On the other side, the last phases are considered critical because they concentrate the core of the deliverables, licensing requirements and Project Design regulation constraints that cannot be avoided and that without them, the Project Design couldn't be develop in appropriate technical, economic and safety conditions.

Another objective of the research was to know and to understand real construction Project Design management, in this case, the construction Project Design of a dam.

The case study method, compared to other gathering systems, provides valuable information related to the stakeholder duties, new documents that were not mentioned in the bibliography reviewed, and the particularities, in this case, of a hydraulics Project Design based in the construction of a dam.

The single case study applied in this research was not enough to refute the life cycle of the Project Design, because the Rebordãos Project Design consisted only in the Design Development Phase and Construction Document Phase due to EU funding issues, instead of the standard structure defined in the bibliographic review.

Another relevant aspect refers to the interview process, that allows getting in contact with the participant members of the Project Design company involved in the construction Project Design and who provided their professional detailed opinion and experience. The conclusion about the interview process is that the more people interviewed, more points of view are analyzed.

On the opposite, the disadvantage of this process is the subjectivity implicit in their opinions, which requires a post-treatment of that information to separate the unreliable and the trustable information.

The Project Design reality shows a different point of view compared to the information included in the bibliography review because it is not mandatory to follow all the phases step by step, being possible to overcome some of them, less relevant, taking into consideration in the content of next developed phases.

Table 5.1, is a summary table that reflects the accomplishment or not of the research objectives.

OBJECTIVE Nº1	To recognize and catch accordingly with current regulations, and based on bibliographical review, the Project Design management life-cycle from the conception to the closeout, considering the particularities of the different stages.
ACCOMPLISHED	NO
COMMENTARIES	Bibliographic review itself cannot be considered as the unique source of information, given the wide number of authors and subjectivity. It is necessary to look for other information gathering methods in order to complement and check the available information.

OBJECTIVE Nº2	To explain the development of a real case study, based on an irrigation dam in Bragança.
ACCOMPLISHED	YES
COMMENTARIES	The existence in Portugal of an irrigation dam construction project in progress, the dam in Ribeira de Rebordãos, and the access to the Project Design from the design company, allowed to explain a real project situation, although it was a particular project given the EU restraints.

OBJECTIVE Nº3	To be understand the differences between a theoretical Project Design management developed according to the current regulation and a real situation Project Design.
ACCOMPLISHED	NO
COMMENTARIES	The fact that the irrigation dam in Ribeira de Rebordão only submitted two of the phases of a theoretical life cycle of a Project Design, turned out impossible to make a trustable comparison. Thus, it is necessary to collect information from more case studies or to apply a different gathering information method.

Table 5-1. Research objectives accomplishment.

5.3 Research limitations

There are some restraints in this research that made not possible to fully accomplish the stablished objectives.

First, the few constructions of dams complicated the task of finding case studies that could complement and add information about the topic, being possible to find only one, the dam construction in Ribeira de Rebordãos.

Another restraint is the number of participants in the interview process. This method is much worthy when the number of participants is higher because it allows to collect more information and to compare them in order to sort and remain with the most trustable and objective one.

Although it was not possible to arrange more participants for the interview, given the restraints previously mentioned, this Project Design was thoroughly studied, to serve as a model to future Project Designs, not being possible to fully understand the basis and criteria that is behind all the decisions taken to evolve into the subsequent phases.

5.4 Research contributions

This research was intended to serve as a baseline in order to understand all the framework of a complete construction Project Design management. The following research contributions can be related:

- The current regulation is brought up in this work, regarding the phases that the Project Design must contain, the duties of the stakeholders, as well as the documents that are required, and when they should be submitted and by who.
- To understand the basis of some decisions, documents and processes that allow the transition to subsequent phases of the Project Design.
- The methodology to gather information is expressed in this work, to show the alternatives that exist in order to get refutable and worthy information to be implemented in other Project Designs with more complexity aspects and differences than in current building Project Designs.

5.5 Future development

Serving as a suggestion, in order to improve the obtained results, the range of study can be extended to other kind of construction projects, apart from the constructions of dams, which is a highly limited kind of projects, in order to have access to more case studies and, thus, extend the information about the process and management of other kind of Project Designs.

Besides that, regarding the interview process, the number of participants can be increased to analyze different points of view of the different Project Designs, to serve as a way to compare and refute the information.

Regarding the bibliographic reviewed, in further researches, it can be considered to analyze more bibliography about economic aspects, to complement the current information. Thus, the Project Design would become more complete, with a wider range of influence.

Moreover, it can be developed a support guide to develop this kind of Project Designs, with higher complexity than the building construction Project Designs.

In addition, it would be helpful to this research, to further detail the decisions and status of the documents that allow the passage to subsequent phases.

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APPENDIX I

Appendix I.1 – Case Study: Interview Quiz Support

Appendix I.2 – Case Study: Interview Answers (Interview Results)

Appendix I.1 – Case Study: Interview Quiz support

B

Interview

Interview by Rubén Quiñones Martínez, aiming to collect information, with academic purposes, in order to develop the Master Project in Construction Engineering at the Polytechnic Institute of Bragança.

1. Client

General scope of the Project Design in terms of tendering, regulation and technical and economic feasibility.

1ª	Was the Site previously defined or it changed after the proposal of the design team?
2ª	Are there minimum requirements defined for the tendering construction companies?
3ª	Are there minimum requirements or constraints that affect the designers?
4ª	Were the owners of the lands affected by the basin compensated?
5ª	Were land expropriations considered?
6ª	Do you consider that the Project Design should be completed with specifications, technical specifications, or any other elements? What were the documents that constituted the specifications?
7ª	Was it considered the tendering process only at a national level or was it extended to an international level?
8ª	What is the expected budget for the Project?
9ª	Does the construction of the dam have any impact on fish spawning?
10ª	Is the client aware of any other impacts that could affect the project?

2. Feasibility Phase

11ª In this Project Design, was it considered the Feasibility Phase? Yes/No (If yes, go to Question 13.)

12ª If the Feasibility Phase was waived, what was the reason? (Go to Question 16).

13ª Was the Feasibility Phase presented by the Owner of work delivered to the design team under acceptable technical conditions?

14ª Was the following information included in the Feasibility Phase?

i. Soil conditions.	YES	NO
ii. Operation.	YES	NO
iii. Exploration and Conservation/Maintenance conditions.	YES	NO
iv. Estimate of the final cost of the project	YES	NO
v. Deadlines for the project completion.	YES	NO

15ª Was it required by the client any document, guarantee or specification to be attended in the Project Design? If yes, which?

3. Programming Phase

16ª In this Project Design, was it considered the Programming Phase? Yes/No (If yes, go to Question 18.)

17ª If the Programming Phase was waived, what was the reason? (Go to Question 24.)

18ª The Programming Phase aims to develop the elements in the Feasibility Phase. Does it include the following content/information??

i. Verification of technical feasibility.	YES	NO
ii. Verification of financial feasibility.	YES	NO
iii. Planning of the Works and phases to be accomplished.	YES	NO
iv. Design pieces.	YES	NO
v. Completion of test and studies (topography and geotechnical).	YES	NO

19ª Were any of this contents developed in the following phases? If yes, which ones?

20ª Regarding the technical approach of the Project Design, was the proposal provided the only solution considered or were there other alternative technical solutions posed as potential hypotheses?

21ª In case of any other technical solutions, could be possible to get to know more information about their aspects and the reason why they were rejected or abandoned?

22ª Regarding the deadlines, ¿What was the deadline to deliver the Programming Phase?

- > 1 Month.
- 1 – 2 Month.
- 2 – 3 Month.
- 3 - 6 Month.
- > 6 Month.

23ª What was the established criteria by the Owner of the work to proceed with the completion of the Programming Phase and the transition to the Schematic Design Phase?

4. Schematic Design Phase

24ª In this Project Design, was it considered the Schematic Design Phase? Yes/No (If yes, go to question 26.)

25ª If the Schematic Design Phase was waived, what was the reason? (Go to question 33.)

26ª The Schematic Design Phase aims to develop the constructive solutions, in this case, the constructive solution of the dam. Is there any document that has been considered and that conditioned the technical solutions submitted?

27ª In order to achieve a better organization and clearance of the process to be develop in the construction of the Project Design, was it elaborated a Work Breakdown Structure (WBS)? Yes/no

28ª The construction of a dam is included in the Category III (Hydraulics projects) apart from the other processes belonging to the resto of categories. According to the current regulation, in this situation, two constructive solutions should be proposed, was this constraint verified in the dam construction Project Design?

29ª What is the estimated budget of the work?

30ª In case of a budget greater than Class 5 (2.800.000 €) a Project Design revision is mandatory. Was it necessary to undertake a Project Design review during the Schematic Design Phase?

31ª Regarding the deadlines, ¿What was the deadline to deliver the Schematic Design Phase?

- > 1 Month.
- 1 – 2 Month.
- 2 – 3 Month.
- 3 - 6 Month.
- > 6 Month.

32ª What was the established criteria by the Owner of the work to proceed with the completion of the Schematic Design Phase and the transition to the Design Development Phase?

5. Design Development Phase

33ª In this Project Design, was it considered the Design Development Phase? Yes/No (If yes, go to question 35.)

34ª If the Design Development Phase was waived, what was the reason? (Go to question 41.)

35ª Did the submitted Design Development Phase, that aims to develop the approved constructive solution, include the following deliverables?

i.	Safety and Health Plan in design phase.	YES	NO
ii.	Map of quantities.	YES	NO
iii.	Observation Plan.	YES	NO
iv.	Project base budget.	YES	NO
v.	Internal Emergency Response Plan.	YES	NO
vi.	Environmental Impact Assessment.	YES	NO
vii.	Construction and Demolition Waste Plan.	YES	NO
viii.	Geotechnical and geologic study.	YES	NO
ix.	Topographic study	YES	NO
x.	Structural and foundations project.	YES	NO
xi.	Electro mechanic project.	YES	NO
xii.	Hydraulic project.	YES	NO
xiii.	Expropriations plan.	YES	NO

36ª Were consider safety measures in the dam? Yes/No. If yes, which?

37ª What were the stages in the licensing process of the works?

38ª Regarding the deadlines, ¿What was the deadline to deliver the Design Development Phase?

- > 1 Month.
- 1 – 2 Month.
- 2 – 3 Month.
- 3 - 6 Month.
- > 6 Month.

39ª What was the established criteria by the Owner of the work to proceed with the completion of the Design Development Phase Study and the transition to the Construction Document Phase?

6. Construction Document Phase

40ª In this Project Design, was it considered the Construction Document Phase? Yes/No (If yes, go to question 42.)

41ª If the Construction Document Phase was waived, what was the reason? (Go to question 47.)

42ª The submitted Construction Document Phase aims to detail all the required elements in order to achieve a good construction of the project. Did the Construction Document Phase include the following content?

i.	Descriptive report.	YES	NO
ii.	Map of quantities.	YES	NO
iii.	Detailed budget.	YES	NO
iv.	Designed pieces.	YES	NO
v.	Technical specifications.	YES	NO
vi.	Contract dossier	YES	NO
vii.	Environmental mitigation	YES	NO
viii.	Landscape Integration Plan	YES	NO
ix.	Construction and Demolition Waste Plan	YES	NO

43ª Apart from these documents, were there more documents that belonged to the Construction Document Phase?

44ª In view of the construction phase, did the contract dossier include the following information?

i.	Designation of the safety coordinator.	YES	NO
ii.	Designation of the supervisor/ supervision team	YES	NO
iii.	Designation of the contractor	YES	NO
iv.	Designation of the technical team of the contractor (Safety responsible, environmental responsible)	YES	NO
v.	Collaboration in the development of the Prior Notification of Site Works yard.	YES	NO

45ª Regarding the deadlines, ¿What was the deadline to deliver the Construction Document Phase?

- > 1 Month.
- 1 – 2 Month.
- 2 – 3 Month.
- 3 - 6 Month.
- > 6 Month.

46ª What was the established criteria by the Owner of the work to proceed with the completion of the Construction Document Phase and the transition to the Project Design Closeout Phase?

7. Project Design Closeout Phase

47ª ¿How was developed the process of Project Design Closeout Phase?

48ª Regarding the deadlines, were there a deadline to get the licensing approval?

- > 1 Month.
- 1 – 2 Month.
- 2 – 3 Month.
- 3 - 6 Month.
- > 6 Month.

49ª In reality, how long did it take to get the approval? How long is the expected timeframe for this kind of projects?

Appendix I.2 – Case Study: Interview answers (Interview results)

Designer Engineer	
1.	Was the Site previously define or it changed after the proposal of the design team?
	It was previously defined.
2.	Are there minimum requirements defined for the tendering construction companies?
	Will be applied the requirement of having performed in the last years a similar work (volume, etc.)
3.	Are there minimum requirements or constraints that affect the design teams.
	The design teams have been chosen based on their resume, as well as the other tenderers.
4.	Were the owners of the lands affected by the basin compensated?
	They will be compensated. A plan was provided to the designers with the lands of the basin area and the lands of each owner.
5.	Were land expropriations considered?
	Yes
6.	Do you consider that the project design should be completed with specifications, technical specifications, or any other elements? What were the documents that constituted the specifications?
	Yes. Program of tender, specifications, technical aspects, technical specifications, Construction Document Phase plus the EIA.
7.	Was it considered the tendering process only at a national level or was it extended to an international level?
	Limit by the European Commission.
8.	What is the expected budget for the Project?
	≈ 3.600.000 €
9.	**Does the construction of the dam have any impact on fish spawning?**
	No
10.	**Is the client aware of any other impacts that could affect the project?**
	Develop in the EIA

Feasibility Phase	
11.	In this Project Design, was it considered the Feasibility Phase? Yes/No (If yes, go to Question 13.)
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12.	If the Feasibility Phase was waived, what was the reason? (Go to Question 16).
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13.	Was the Feasibility Phase presented by the Owner of work delivered to the designer under acceptable technical conditions?
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14.	Was the following information included in the Feasibility Phase? i. Soil conditions. YES NO ii. Operation. YES NO iii. Exploration and Conservation/Maintenance conditions. YES NO iv. Estimate of the final cost of the project YES NO v. Deadlines for the project completion. YES NO
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15.	Was it required by the client any document, guarantee or specification to be attended in the Project Design? If yes, which?
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Programming Phase	
16.	In this Project Design, was it considered the Programming Phase? Yes/No (If yes, go to Question 18.)
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17.	If the Programming Phase was waived, what was the reason? (Go to Question 24.)
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18.	The Programming Phase aims to develop the elements in the Feasibility Phase. Does it include the following content/information?? i. Verification of technical feasibility. YES NO ii. Verification of financial feasibility. YES NO iii. Planning of the Works and phases to be accomplished. YES NO iv. Design pieces. YES NO v. Completion of test and studies (topography and geotechnical) YES NO
19.	Were any of this contents developed in the following phases? If yes, which ones?
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20.	Regarding the technical approach of the Project Design, was the proposal provided the only solution considered or were there other alternative technical solutions posed as potential hypotheses?
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21.	In case of any other technical solutions, could be possible to get to know more information about their aspects and the reason why they were rejected or abandoned?
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22.	Regarding the deadlines, ¿What was the deadline to deliver the Programming Phase? o > 1 Month. o 1 – 2 Month. o 2 – 3 Month. o 3 - 6 Month. o > 6 Month.
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23.	What was the established criteria by the Owner of the work to proceed with the completion of the Programming Phase and the transition to the Schematic Design Phase?
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Schematic Design Phase	
24.	In this Project Design, was it considered the Schematic Design Phase? Yes/No (If yes, go to question 26.)
	Yes
25.	If the Schematic Design Phase was waived, what was the reason? (Go to question 33.)
	-
26.	The Schematic Design Phase aims to develop the constructive solutions, in this case, the constructive solution of the dam. Is there any document that has been considered and that conditioned the technical solutions submitted?
	No, we analyzed the documents on location, hydrology, hydraulics, structures, costs and energy production.
27.	In order to achieve a better organization and clearance of the process to be develop in the construction of the Project, was it elaborated a Work Breakdown Structure (WBS)? Yes/no
	Yes, but only in the Construction Document Phase.
28.	The construction of a dam is included in the Category III (Hydraulics projects) apart from the other processes belonging to the resto of categories. According to the current regulation, in this situation, two constructive solutions should be proposed, Was this constraint verified in the dam construction Project Design?
	No, for logical reasons (there was not enough land for an onshore dam and the rockfill system was very complex), the concrete option was the only one possible.
29.	What is the estimated budget of the work?
	≈ 3.600.000 €
30.	In case of a budget greater than Class 5 (2.800.000 €) a project revision is mandatory. Was it necessary to undertake a Project review during the Schematic Design Phase?
	Budget of the Dam: 2.000.000€. Not necessary.

31.	Regarding the deadlines, ¿What was the deadline to deliver the Schematic Design Phase? o > 1 Month. o 1 – 2 Month. o 2 – 3 Month. o 3 - 6 Month. o > 6 Month.
32.	What was the established criteria by the Owner of the work to proceed with the completion of the Preliminary Study and the transition to the Base Project?
	Prove of feasibility

Design Development Phase	
33.	In this Project Design, was it considered the Design Development Phase? Yes/No (If yes, go to question35.)
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34.	If the Design Development Phase was waived, what was the reason? (Go to question 41.)
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35.	Did the submitted Design Development Phase, that aims to develop the approved constructive solution, include the following deliverables? i. Safety and Health Plan in design phase. YES NO ii. Map of quantities. YES NO iii. Observation Plan. YES NO iv. Project base budget. YES NO v. Internal Emergency Response Plan. YES NO vi. Environmental Impact Assessment. YES NO vii. Construction and Demolition Waste Plan. YES NO viii. Geotechnical and geologic study. YES NO

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	ix. Topographic study	YES NO
	x. Structural and foundations project.	YES NO
	xi. Electro mechanic project.	YES NO
	xii. Hydraulic project.	YES NO
	xiii. Expropriations plan.	YES NO
	Developed in the Construction Document Phase	
36.	Were consider safety measures in the dam? Yes/No. If yes, which?	
	Yes. Measures included in the EIA.	
37.	What were the stages in the licensing process of the works?	
	1st Stage: City Hall and LNEC 2nd Stage: EIA - APA	
38.	Regarding the deadlines, ¿What was the deadline to deliver the Design Development Phase? o > 1 Month. o 1 – 2 Month. o 2 – 3 Month. o 3 - 6 Month. o > 6 Month.	
39.	What was the established criteria by the Owner of the work to proceed with the completion of the Design Development Phase and the transition to the Construction Document Phase?	
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Construction Document Phase	
40.	In this Project Design, was it considered the Construction Document Phase? Yes/No (If yes, go to question 42.)
	Yes
41.	If the Construction Document Phase was waived, what was the reason? (Go to question 47.)
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42.	50ª The submitted Construction Document Phase aims to detail all the required elements in order to achieve a good execution of the project. Did the Construction Document Phase include the following content? i. Descriptive report. YES NO ii. Map of quantities. YES NO iii. Detailed budget. YES NO iv. Designed pieces. YES NO v. Technical specifications. YES NO vi. Contract dossier YES NO vii. Environmental mitigation YES NO viii. Landscape Integration Plan YES NO ix. Construction and Demolition Waste Plan YES NO
	All of them
43.	Apart from these documents, were there more documents that belonged to the Construction Document Phase?
	No

Construction Document Phase	
44.	In view of the construction phase, did the contract dossier include the following information? vi. Designation of the safety coordinator. YES NO vii. Designation of the supervisor/ supervision team YES NO viii. Designation of the contractor YES NO ix. Designation of the technical team of the contractor (Safety responsible, environmental responsible) YES NO x. Collaboration in the development of the Prior Notification of Site Works yard. YES NO
	All of them
45.	Regarding the deadlines, ¿What was the deadline to deliver the Construction Document Phase? o > 1 Month. o 1 – 2 Month. o 2 – 3 Month. o 3 - 6 Month. o > 6 Month.
	It took 9 months because the base project was considered in the Construction Document Phase.
46.	What was the established criteria by the Owner of the work to proceed with the completion of the Construction Document Phase and the transition to the Project Closeout Phase?
	The tendering criteria

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Project Closeout Phase	
47.	How was developed the process of Project Closeout Phase?
	The Project Design is handed over to the owner of the project (City Hall), who processes the licenses and is in charge of the rest of the processes.
48.	Regarding the deadlines, were there a deadline to get the licensing approval? o > 1 Month. o 1 – 2 Month. o 2 – 3 Month. o 3 - 6 Month. o > 6 Month.
49.	In reality, how long did it take to get the approval? How long is the expected timeframe for this kind of projects?
	Unknown yet.

Choosen answer.

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